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Ontario Geological Survey
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Every possible effort is made to ensure the accuracy of the information contained in this report, but the Ministry of Natural Resources does not assume any liability for errors that may occur. Source references are included in the report and users may wish to verify critical information.

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CONTENTS

	Page
Abstract	v
Introduction	1
Part I - Inventory Methods	2
Field and Office Methods	2
Resource Tonnage Calculation Techniques	2
Sand and Gravel Resources	2
Bedrock Resources	3
Units and Definitions	3
Part II - Data Presentation and Interpretation	4
Map 1 Distribution of Sand and Gravel Deposits	4
Deposit Symbol	4
Texture Symbol	4
Map 2 Selected Sand and Gravel Resource Areas	5
Site Specific Criteria	5
Deposit Size	5
Aggregate Quality	5
Location and Setting	6
Regional Considerations	7
Map 3 Bedrock Resources	7
Selection Criteria	7
Selected Resource Areas	8
Part III - Assessment of Aggregate Resources in the Town of Newcastle	9
Location and Population	9
Physiography and Surficial Geology	9
Extractive Activity	10
Selected Sand and Gravel Resource Areas	10
Selected Sand and Gravel Resource Area 1	11
Selected Sand and Gravel Resource Area 2	11
Sand and Gravel Resource Areas of Secondary Significance	12
Bedrock Geology	12
Summary	13
References	27
Appendix A - Suggested Additional Reading	29
Appendix B - Glossary	30
Appendix C - Geology of Sand and Gravel Deposits	33
Appendix D - Geology of Bedrock Deposits	35

TABLES

1 - Total Sand and Gravel Resources, Town of Newcastle	14
2 - Sand and Gravel Pits, Town of Newcastle	15
3 - Selected Sand and Gravel Resource Areas, Town of Newcastle	19
4 - Total Identified Bedrock Resources, Town of Newcastle	20
5 - Quarries, Town of Newcastle	21
6 - Selected Bedrock Resource Areas, Town of Newcastle	22
7 - Summary of Test Hole Data, Town of Newcastle	23
8 - Described Sections, Town of Newcastle	24

FIGURES

1 - Key Map Showing Location of the Town of Newcastle	v
2a - Aggregate Grading Curves, Town of Newcastle	25
2b - Aggregate Grading Curves, Town of Newcastle	26
3 - Bedrock Geology of Southern Ontario	35

MAPS
(back pocket)

1 - Distribution of Sand and Gravel Deposits, Town of Newcastle, Scale 1:50 000.
2 - Selected Sand and Gravel Resource Areas, Town of Newcastle, Scale 1:50 000.
3 - Bedrock Resources, Town of Newcastle, Scale 1:50 000.

ABSTRACT

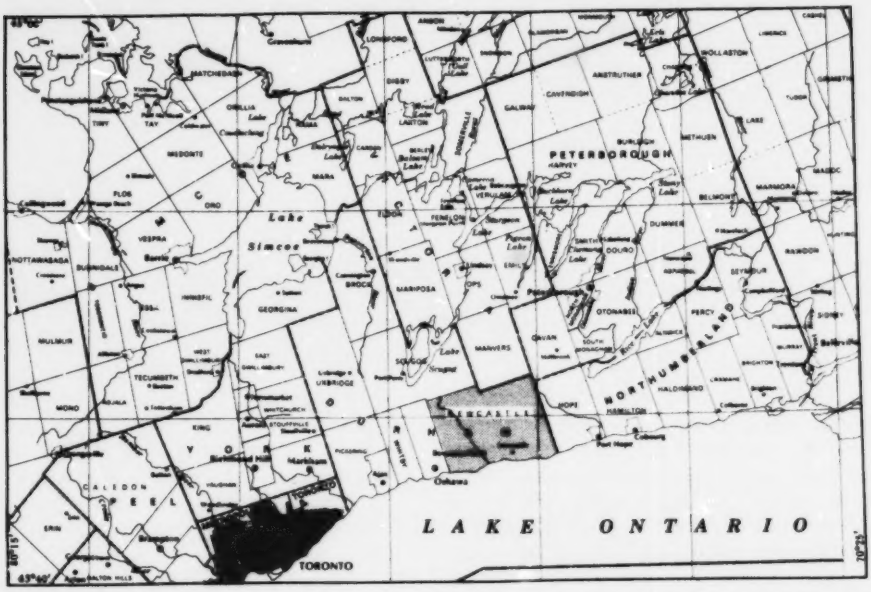


Figure 1 - Key Map Showing the Location of the Town of Newcastle, Scale 1:1 800 000.

This report includes both an inventory and evaluation of sand and gravel as well as bedrock resources in the Town of Newcastle. The report is part of the Aggregate Resources Inventory Program for townships and municipalities designated under The Pits and Quarries Control Act, 1971.

In the Town of Newcastle, two areas containing significant amounts of sand and gravel have been selected for possible resource protection at the primary level of significance. These areas include a large ice-contact deposit located along the town's northern boundary and three glaciolacustrine beach deposits situated in the south-central part of the town. The Selected Sand and Gravel Resource Areas occupy 11,200 acres (4550 ha), exclusive of licenced areas. An estimated 8700 acres (3500 ha) are potentially available for extraction, containing resources of approximately 640 million tons (580 million tonnes). The parts of the selected areas which are available for extraction represent 14 percent of the total area occupied by sand and gravel deposits in the town and 16 percent of the original resource tonnage.

A very large deposit of ice-contact stratified drift in the Oak Ridges Moraine and two smaller ice-contact deposits have been selected as Sand and Gravel Resource Areas of Secondary Significance. These deposits are relatively unexploited but they may contain a considerable quantity of sand and gravel. Further field investigation would be required to identify specific sites suited for extractive development.

The Town of Newcastle has sufficient sand and gravel resources to meet local needs for a considerable period of time. However, possible resources of crushable gravel are limited. Care should be taken to ensure the continuing availability of as much of the remaining resources as possible.

The surficial deposits are underlain by Ordovician limestone of the Lindsay Formation and shale of the Whitby Formation. The Lindsay strata have been extracted for use as a raw material in cement manufacture by the St. Marys Cement Company at Bowmanville, but no areas have been selected for possible resource protection because of the general thick drift cover.

Selected Resource Areas are not intended to be permanent, single land use units which must be incorporated in an official planning document. They represent areas in which a major resource is known to exist. Such Resource Areas may be reserved wholly or partially for extractive development and/or resource protection within the context of the official plan.

AGGREGATE RESOURCES INVENTORY OF THE TOWN OF NEWCASTLE[1]

BY
STAFF OF THE ENGINEERING
AND TERRAIN GEOLOGY SECTION

INTRODUCTION

Mineral aggregates, which include bedrock-derived crushed stone as well as naturally formed sand and gravel, constitute the major raw material in Ontario's road-building and construction industries. Very large amounts of these materials are used each year throughout the Province. For example, in 1979, the total tonnage of mineral aggregates extracted was 144 million tons (131 million tonnes), greater than that of any other metallic or nonmetallic commodity mined in the Province (Ontario Ministry of Natural Resources 1980).

Although mineral aggregate deposits are plentiful in southern Ontario, they are fixed-location, nonrenewable resources which can be exploited only in those areas where they occur. Mineral aggregates are characterized by their high bulk and low unit value so that the economic value of a deposit is a function of its proximity to a market area as well as its quality and size. The potential for extractive development is usually greatest in urban fringe areas where land use competition is extreme. For these reasons the availability of adequate resources for future development is now being threatened in some areas.

Comprehensive planning and resource management strategies are required to make the best use of available resources, especially in those areas experiencing rapid development. Such strategies must be based on a sound knowledge of the total mineral aggregate resource base at both local and regional levels. The purpose of the Aggregate Resources Inventory is to provide the basic geological information required to include potential mineral aggregate resource areas in planning strategies and official plans. The reports should form the basis for discussion on those areas best suited for possible extraction. The aim is to assist decision-makers in protecting the public well-being by ensuring that adequate resources of mineral aggregate remain available for future use.

This report is a technical background document, based for the most part on geological information and interpretation. It has been designed as a component of the total planning process and should be used in conjunction with other planning considerations, to ensure the best use of a municipality's resources.

The report includes an assessment of sand, gravel and crushed bedrock. The most recent information available has been used to prepare the reports. As new information becomes available, revisions may be necessary.

[1] Manuscript accepted for publication by Chief, Engineering and Terrain Geology Section, April 30, 1984.
This paper is published with the permission of V.G. Milne, Director, Ontario Geological Survey.

PART I - INVENTORY METHODS

FIELD AND OFFICE METHODS

The methods used to prepare the report primarily involve the interpretation of published geological data such as bedrock and surficial geology maps and reports (see References). Field methods included the examination of natural and man-made exposures of granular material. Most observations were made at quarries and sand and gravel pits located from records held by the Ontario Ministry of Transportation and Communications, the Ontario Geological Survey, and by Regional and District Offices of the Ontario Ministry of Natural Resources. Observations made at pit sites included estimates of the total face height and the proportion of gravel- and sand-sized fragments in the deposit. Observations were also made of the shape and lithology of the particles. These characteristics are important in estimating the quality and quantity of the aggregate. In areas of limited exposure, test pitting, soil probing and hand-augering techniques were used to assess subsurface materials. Airphotos at various scales were used to determine the continuity of deposits, especially in areas of limited subsurface information.

Deposits with potential for further extractive development or those where existing data are scarce, were studied in greater detail. Representative layers in these deposits were sampled in 25- to 100-pound (11 to 45 kg) units either from existing pit faces or from test pits dug by backhoe. The samples were analysed for grain size distribution and in some cases for petrographic assemblage. Analyses were performed by the laboratories of the Soils and Aggregates Section, Engineering Materials Office, Ontario Ministry of Transportation and Communications. In areas of limited subsurface exposure, drilling using a powered hollow stem auger was undertaken. The stratigraphic sections in these test holes are described in drill logs included in the report as Table 7. In some cases samples taken during the course of the drilling were analysed to determine grain size distribution. The symbols for and locations of test hole sites are noted on Map 1.

In the office, the pit and field sample data were supplemented by information on file with the Soils and Aggregates Section of the Ontario Ministry of Transportation and Communications. Data contained in these files include field estimates of the depth, composition and "workability" of deposits as well as laboratory analyses of the physical properties and chemical suitability of the aggregate. Information concerning the development history of the pits and acceptable uses of the aggregate is also recorded. The location, size, and depth of extraction of pits licenced under The Pits and Quarries Control Act, 1971 were obtained from records held by Regional and District Offices of the Ontario Ministry of Natural Resources. The cooperation of the above named groups in the compilation of inventory data is gratefully acknowledged.

Water well records, held by the Ontario Ministry of the Environment, were used in some areas to corroborate thickness estimates, or to indicate the presence of buried granular material. These records were used only in conjunction with other evidence. Soil reports published by the Ontario Ministry of Agriculture and Food were also consulted in order to supply additional information in areas with limited data. Topographic maps of the National Topographic System, at a scale of 1:50 000, were used as a compilation base for the field and office data. The information was then transferred to a township base map, also at a scale of 1:50 000, prepared by the Cartography Section of the Lands and Waters Group, Ontario Ministry of Natural Resources, for presentation in the report.

RESOURCE TONNAGE CALCULATION TECHNIQUES

SAND AND GRAVEL RESOURCES

Once the interpretative boundaries of the aggregate units have been drawn, quantitative estimates of the possible resources available can be made. Generally, the volume of a deposit can be calculated if its areal extent and average thickness are known or can be estimated. The computation methods used are as follows. First, the area of the deposit, as outlined on the final base map, is calculated in acres. The thickness values used are an approximation of the deposit thickness, based on the face heights of pits developed in the deposit or on subsurface data

such as test holes and water well logs. Original tonnage values can then be calculated by multiplying the volume of the deposit by 2500 (the density factor). This factor is approximately the number of tons in a one-foot (0.3 m) thick layer of sand and gravel, one acre (0.4 ha) in extent, assuming an average density of 110 pounds per cubic foot (1766 kg per cubic metre).

Tonnage = Area x Thickness x Density Factor

Tonnage calculated in this manner must be considered only as an estimate. Furthermore, such tonnages represent amounts that existed prior to any extraction of material (i.e. original tonnage) (Table 1, Column 4).

The Selected Sand and Gravel Resource Areas in Table 3 represent only those parts of the deposit lying outside licenced areas (Column 2). Two successive subtractions are made from the unlicenced area. Column 3 accounts for the number of acres unavailable due to the presence of permanent cultural features and their associated setback requirements. Column 4 accounts for those areas lying outside of licenced properties that have previously been extracted (e.g. wayside pits are included in this category). The remaining figure is the area of the deposit currently available for extraction (Column 5). The available area is then multiplied by the estimated deposit thickness and the density factor (Column 5 x Column 6 x 2500) to give an estimate of the sand and gravel tonnage (Column 7) presently available for extractive development and/or resource protection.

BEDROCK RESOURCES

The method used to calculate resources of bedrock-derived aggregate is much the same as that described above. The areal extent of favorable bedrock formations overlain by less than 50 feet (15 m) of unconsolidated overburden is determined from bedrock geology maps, drift thickness and bedrock topography maps and from the interpretation of water well records. The measured extent of such areas is then multiplied by the estimated workable thickness of the formation, based on stratigraphic analyses and on estimates of existing quarry faces in the unit. In some cases a standardized estimate of a workable thickness of 60 feet (18 m) is used. Volume estimates are then multiplied by 3600 (the estimated weight in tons of a one-foot (0.3 m) thick section of dolostone, one acre (0.4 ha) in extent, assuming a bulk density of 165 pounds per cubic foot (2649 kg per cubic metre)).

Resources of sandstone are calculated using a bulk density estimate of 146 pounds per cubic foot (2344 kg per cubic metre) or approximately 3200 tons per acre (7173 tonnes per hectare). Shale resources are calculated on the basis of a bulk density estimate of 150 pounds per cubic foot (2408 kg per cubic metre).

UNITS AND DEFINITIONS

Although most of the measurements and other primary data available for resource tonnage calculations are given in Imperial units, Metric units have also been given in the text and on the tables which accompany the report. The Metric equivalent of the data is shown in brackets after or directly below the corresponding Imperial figures. Data are generally rounded off in accordance with the Ontario Metric Practice Guide (Metric Committee 1975).

The tonnage estimates made for sand and gravel as well as bedrock-derived aggregates are termed possible resources in accordance with terminology of the Ontario Resource Classification Scheme (Robertson 1975, p. 7) and with the Association of Professional Engineers of Ontario (1976) (see Glossary, Appendix B).

PART II - DATA PRESENTATION AND INTERPRETATION

Three maps, each portraying a different aspect of the aggregate resources in the municipality, accompany the report. Map 1, "Distribution of Sand and Gravel Deposits", gives a comprehensive inventory of the sand and gravel resources in the report area. Map 2, "Selected Sand and Gravel Resource Areas", shows those deposits which are considered to represent the largest and/or highest quality resources in the area. Map 3, "Bedrock Resources", shows the distribution of bedrock formations, the thickness of overlying unconsolidated sediments, and identifies the Selected Bedrock Resource Areas.

MAP 1: DISTRIBUTION OF SAND AND GRAVEL DEPOSITS

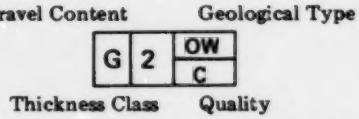
Map 1 is derived directly from the existing surficial geology maps of the area or from airphoto and field interpretation where surficial mapping is incomplete. It shows the extent and quality of sand and gravel deposits within the study area and the present level of extractive activity.

The present level of extractive activity in the study area is indicated as follows. Those areas which are licenced for extraction under The Pits and Quarries Control Act, 1971 are shown by a solid outline and identified by a number which refers to the pit descriptions in Table 2. Each description notes the owner, location and licenced acreage of the pit, as well as the estimated face height and percentage gravel. A number of unlicenced pits (abandoned pits or wayside pits operating on demand under authority of a permit) are also identified and numbered on Map 1 and described in Table 2.

Map 1 also presents a summary of available information related to the quality of aggregate contained in all the known aggregate deposits in the study area. Much of this information is contained in the symbols which are found on the map. The Deposit Symbol appears for each mapped deposit and summarizes important genetic and textural data. The Texture Symbol is a circular proportional diagram which displays the grain size distribution of the aggregate in areas where bulk samples were taken.

DEPOSIT SYMBOL

The Deposit Symbol is similar to those used in soil mapping and land classification systems commonly in use in North America. The components of the symbol indicate the gravel content, thickness of material, origin (type), and quality limitations for a given deposit. These components are illustrated by the following example:



This symbol identifies an outwash deposit 10 to 20 feet (3 to 6 m) thick containing more than 35 percent gravel. Excess silt and clay may limit uses of the aggregate in the deposit.

The "gravel content" and "thickness class" are basic criteria for distinguishing different deposits. The "gravel content" symbol is an upper case "S" or "G". The "S" indicates that the deposit is generally "sandy" and that gravel-sized aggregate (greater than 4.75 mm) makes up less than 35 percent of the whole deposit. "G" indicates that the aggregate probably contains more than 35 percent gravel.

The "thickness class" indicates a depth range which is related to the potential resource tonnage for each deposit. Four thickness class divisions have been established as shown in the legend for Map 1.

Two smaller sets of letters, divided from each other by a horizontal line, follow the thickness class number. The upper series of letters identify the geologic deposit type (the types are summarized with respect to their main geologic and extractive characteristics in Appendix C) and the lower series of letters identify the main quality limitations that may be present in the deposit, as discussed in the next section.

TEXTURE SYMBOL

The Texture Symbol provides a more detailed assessment of the grain size distribution in deposits where samples were taken for analysis during field study. The data from which these symbols are derived has been plotted on grain size distribution graphs. The relative amounts of gravel, sand, silt, and clay in the sampled material are shown graphically by the sub-

division of a circle into proportional segments. The following example shows a hypothetical sample consisting of 30 percent gravel, 60 percent sand, and 10 percent silt and clay:

Test hole locations are shown on Map 1 by a solid drill hole symbol.

MAP 2: SELECTED SAND AND GRAVEL RESOURCE AREAS

Map 2 is an interpretative map derived from an evaluation of the deposits shown on Map 1. The deposits identified on Map 2 are those which are considered to be important in ensuring an adequate resource base for the future.

All the selected sand and gravel resource areas are first delineated by geological boundaries and then classified into three levels of significance: primary; secondary; and tertiary. These areas are identified on Map 2 by different shading patterns. Each area of primary significance is assessed as to its probable relative value as a resource in the municipality and is given a deposit number which denotes its ranking order. All such deposits are shown by a dark shading on Map 2.

Selected Sand and Gravel Resource Areas of primary significance are not permanent, single land use units which must be incorporated in an official planning document. They represent areas in which a major resource is known to exist. Such Resource Areas may be reserved wholly or partially for extractive development and/or resource protection within the context of the official plan.

Deposits of secondary significance are not ranked numerically in this report, but are indicated by a light shading on Map 2. Such deposits are believed to contain significant amounts of sand and gravel. Although deposits of secondary significance are not considered to be the "best" resource areas in a municipality, they may contain large quantities of sand and gravel and should be considered an integral component of the aggregate supply of the municipality.

Areas of tertiary significance are indicated on the map by a dashed line but have no shading. They are neither rated nor considered to be important resource areas because of their low available resources, or because of possible difficulties in extraction. Such areas may be useful for local needs but are unlikely to support large-scale development.

The process by which deposits are evaluated and selected involves the consideration of two sets of criteria. The main selection criteria are site specific, related to the characteristics of individual deposits. Factors such as deposit size, aggregate quality, and deposit location and setting are considered in the selection of those deposits best suited for extractive development. A second set of criteria involves the assessment of local aggregate resources in relation to the quality, quantity, and distribution of resources in the region in which the municipality is located. The intent of such a process of evaluation is to ensure the continuing availability of sufficient resources to meet possible future demands.

SITE SPECIFIC CRITERIA

DEPOSIT SIZE

Ideally, selected deposits should contain available sand and gravel resources large enough to support a commercial pit operation using a stationary or portable processing plant. In practice, much smaller deposits may be of significant value depending on the overall reserves in the rest of the municipality. Generally, deposits in Class 1, i.e. those thicker than 20 feet (6m) and containing more than 35 percent crushable gravel are considered to be most favourable for commercial development. Thinner deposits may be valuable in municipalities with low total resources.

AGGREGATE QUALITY

The limitations of natural aggregates for various uses result from variations in the lithology of the particles composing the deposit, and from variations in the size distribution of these particles.

Four indicators of the quality of aggregate may be included in the symbol for each deposit on Map 1. They are: gravel content (G or S); fines (C); oversize (O); and lithology (L).

Three of the indicators deal with grain size distribution. The gravel content (G or S) indi-

cates the suitability of aggregate for various uses. Deposits containing at least 35 percent gravel in addition to a minimum of 20 percent material greater than the 26.5 mm sieve are considered to be the most favourable extractive sites, since this content is the minimum from which crushed products can be economically produced.

Excess fines (or high silt and clay content) may severely limit the potential use of an aggregate. Fines content in excess of 10 percent may impede drainage in road sub-base aggregate and render it more susceptible to the effects of frost action. In asphaltic aggregate, excess fines hinder the bonding of particles. Deposits known to have a high fines content are indicated by a "C" in the quality portion of the Deposit Symbol.

Deposits containing more than 20 percent oversize material (greater than 4 inches (10 cm) in diameter) may also have use limitations. The oversize component is unacceptable for all concrete aggregate and for road-building aggregate, so it must be either crushed or removed during processing. Deposits known to have an appreciable oversize component are indicated by an "O" in the quality portion of the Deposit Symbol.

The other indicator of the quality of an aggregate is lithology. Just as the unique physical and chemical properties of bedrock formations determine their value for use as crushed rock, so do various lithologies of particles in a sand and gravel deposit determine its suitability for various uses. The presence of objectionable lithologies such as chert, siltstone, and shale, even in relatively small amounts, can result in a reduction in the quality of an aggregate, especially for high-quality uses such as concrete or structures. Deposits known to contain objectionable lithologies are indicated by an "L" in the quality component of the Deposit Symbol.

If the Deposit Symbol indicates either "C", "O", or "L" or any combination, the quality of the deposit is considered to be reduced for some uses of the aggregate. No attempt has been made to quantify the degree of limitation imposed. Assessment of the four indicators is made from published data, from data contained in files of the Ontario Ministry of Transportation and Communications and the Engineering and Terrain Geology Section of the Ontario Geological Survey, and from field observations. The Engineering Materials Office of the Ontario Ministry of Transportation and Communications has recently compiled a detailed assessment of aggregate suitability for selected areas in southern Ontario. This material has been consulted extensively in preparation of the inventory reports.

Analyses of unprocessed samples obtained from test holes and pits have been plotted on grain size distribution graphs. On the graphs are the gradation specification envelopes for Ontario Ministry of Transportation and Communications' products -- Granular Base Course A,B, and C; and Hot-Laid Asphaltic Sand Nos. 1, 2, 3, 4, 5, 6 and 8. By plotting the gradation curves with respect to the specification envelopes, it can be determined how well the unprocessed sampled material meets the criteria for each product.

LOCATION AND SETTING

The location and setting of a resource area has a direct influence on its value for possible extraction. The evaluation of a deposit's setting is made on the basis of those natural and man-made features which may limit or prohibit extractive development.

First, the physical context of the deposit is considered. Deposits with some physical constraint on extractive development, such as thick overburden or high water table, are less valuable resource areas because of the difficulties involved in resource recovery. Second, permanent man-made features, such as roads, railways, power lines, and housing developments, which are built on a deposit, may prohibit its extraction. The constraining effect of legally required setbacks surrounding such features is included in the evaluation. A quantitative assessment of these constraints can be made by measurement of their areal extent directly from the topographic maps. The area rendered unavailable by these features is shown for each resource area in Table 3 (Column 3).

The assessment of sand and gravel deposits and bedrock resource areas with respect to local land use and to private land ownership is an important component of the general evaluation process. These aspects of the evaluation process are not considered further in this report but

readers are encouraged to discuss them with personnel of the pertinent District Office of the Ontario Ministry of Natural Resources.

REGIONAL CONSIDERATIONS

In selecting sufficient areas for resource development, it is important to assess both the local and the regional resource base, and to forecast future production and demand patterns.

Some appreciation of future aggregate requirements in an area may be gained by assessing its present production levels and by forecasting future production trends. Such an approach is based on the assumptions that production levels in an area closely reflect the demand and that the present production "market share" of an area will remain at roughly the same level.

The aggregate resources in the region surrounding a municipality should be assessed in order to properly evaluate specific resource areas and to adopt optimum resource management plans. For example, a municipality that has large resources in comparison to its surrounding region constitutes a regionally significant resource area. Municipalities with high resources in proximity to large demand centres, such as metropolitan areas, are special cases.

Although an appreciation of the regional context is required to develop comprehensive resource management techniques, such detailed evaluation is beyond the scope of this report. The selection of resource areas made in this study is based primarily on geological data or on considerations outlined in preceding sections.

MAP 3: BEDROCK RESOURCES

Map 3 is an interpretative map derived from bedrock geology, bedrock topography, drift thickness maps, water well data from the Ontario Ministry of the Environment, oil and gas well data from the Petroleum Resources Section (Ontario Ministry of Natural Resources), and from geotechnical test hole data from various sources. Map 3 is based on concepts similar to those outlined for Maps 1 and 2, but displays both the inventory and evaluation on the one map.

The geological boundaries of the bedrock units are shown by a dashed line. Isolated outcrops are indicated by an "X". Three sets of contour lines delineate areas of less than 3 feet (1 m) of drift, areas of 3 to 25 feet (1 to 8 m) of drift, and areas of 25 to 50 feet (8 to 15 m) of drift. The extent of the areas of thin drift are shown by three shades. The darkest shade indicates areas where bedrock outcrops or is within 3 feet (1 m) of the ground surface. These areas constitute potential resource areas of primary significance because of their easy access. The medium shade indicates areas where drift cover is up to 25 feet (8 m) thick. Quarrying is possible in this depth of overburden and these also represent potential resource areas. The lightest shade indicates bedrock areas overlain by 25 to 50 feet (8 to 15 m) of overburden. These latter areas constitute resources which have extractive value only in specific circumstances. Outside of these delineated areas the bedrock can be assumed to be covered by more than 50 feet (15 m) of overburden, a depth generally considered to be too great to allow economic extraction (unless part of the overburden is composed of economically attractive sand and gravel deposits).

Other inventory information presented on Map 3 is designed to give an indication of the present level of extractive activity in the municipality. Those areas which are licenced for extraction under The Pits and Quarries Control Act, 1971 are shown by a solid outline and identified by a number which refers to the quarry descriptions in Table 5. Each description notes the owner, location, and licenced acreage of the quarry and an estimate of face height. Unlicenced quarries (abandoned quarries or wayside quarries operating on demand under authority of a permit) are also identified and numbered on Map 3 and described in Table 5. One additional symbol appears on the map: an open dot indicates the location of a selected well which penetrates bedrock. The overburden thickness is shown in feet beside the open dot.

SELECTION CRITERIA

Criteria equivalent to those used for sand and gravel deposits are used to select bedrock areas most favourable for extractive development.

The evaluation of bedrock resources is made primarily on the basis of performance and suitability data established by laboratory testing at the Ontario Ministry of Transportation and

Communications. The main characteristics and uses of the bedrock formations found in southern Ontario are summarized in Appendix D.

Deposit "size" is related directly to the areal extent of thin drift cover overlying favourable bedrock formations of sufficient thickness to support quarry operations. Since vertical and lateral variations in bedrock units are much more gradual than in sand and gravel deposits, the quality and quantity of the resource is usually consistent over large areas.

Quality of the aggregate derived from specific bedrock units is established by the performance standards previously mentioned. Location and setting criteria and regional considerations are identical to those for sand and gravel deposits.

SELECTED RESOURCE AREAS

Selection of Bedrock Resource Areas has been restricted to a single level of significance. Three factors support this approach. First, quality and quantity variations are gradual. Second, the areal extent of a given quarry operation is much smaller than that of a sand and gravel pit producing an equivalent tonnage of material, and third, since crushed bedrock has a higher unit value than sand and gravel, longer haul distances can be considered. These factors allow the identification of alternative sites having similar development potential. The Selected Areas are shown on Map 3 by a line pattern and the calculated available tonnages are given in Table 6.

Selected Bedrock Resource Areas shown on Map 3 are not permanent, single land use units which must be incorporated in an official planning document. They represent areas in which a major bedrock resource is known to exist. Such a resource area may be reserved wholly or partially for extractive development and/or resource protection within the context of the official plan.

PART III - ASSESSMENT OF AGGREGATE RESOURCES IN THE TOWN OF NEWCASTLE

LOCATION AND POPULATION

The Town of Newcastle occupies an area of 142,303 acres (57 590 ha) in the southeastern part of the Regional Municipality of Durham. The town was formed during the incorporation of the regional municipality in 1973, and includes the former townships of Darlington and Clarke. Newcastle is shown on parts of the Scugog (31 D/2), Rice Lake (31 D/1), Oshawa (30 M/15) and Port Hope (30 M/16) map sheets of the National Topographic System at a scale of 1:50 000.

The population of the Town of Newcastle was 31 906 in 1982, an increase of 14 percent since 1973 (Ontario Ministry of Municipal Affairs and Housing 1984; Ontario Ministry of Treasury, Economics and Intergovernmental Affairs 1974). The population of the town may continue to increase because of the eastward expansion of the City of Oshawa, the growth of the communities of Bowmanville and Newcastle, and the increased rural-residential development. Such population growth may increase the demand for sand and gravel supplies for road building and construction.

The existing road network in the town provides good access. Gravel-surfaced township roads, together with paved regional roads and King's Highways 401, 2, 115 and 35, form a grid pattern across the area. Newcastle is also served by lines of both the Canadian National and Canadian Pacific Railways.

PHYSIOGRAPHY AND SURFICIAL GEOLOGY

The physiography and distribution of unconsolidated sediments, including sand and gravel deposits, are the result of glacial activity which took place during the Late Wisconsinan Substage of the Pleistocene Epoch, informally known as the 'Great Ice Age'. The Late Wisconsinan lasted from approximately 23 000 to 10 000 years ago, and was marked by the repeated advance and melting back of massive, continental ice sheets.

Two lobes of the continental ice sheet covered the Newcastle area during the Wisconsinan. One lobe occupied the Lake Simcoe basin and advanced from the north while the other advanced northwest from the Lake Ontario basin (Gwyn 1975). The two lobes were confluent or in close proximity during much of Late Wisconsinan time. During periodic climatic warming trends, meltwaters flowing off the ice masses deposited large amounts of sediment between the lobes forming a broad hummocky ridge. This ridge is known as the Oak Ridges Moraine (Chapman and Putnam 1966, pp. 276-280) and is a prominent physiographic feature in southern Ontario.

The Oak Ridges Moraine extends across the northern part of the Town of Newcastle. The feature has a maximum elevation of more than 1300 feet (395 m) above sea level (a.s.l.), with variable local relief. The internal structure of the moraine is complex, having been influenced by several advances and retreats of the ice margins. The moraine consists of stratified sand, gravel and silt with minor amounts of incorporated till (Gravenor 1957). The moraine is an important source of aggregate in the Town of Newcastle.

The last advance of the Lake Ontario lobe deposited the silty Halton Till (Gwyn 1976). The ice advanced as far north as the southern slope of the moraine burying a considerable amount of morainic sediment beneath the till. Older till is also present in the area. For example, sandy silt till is present in the core of drumlins near Leskard and Kendal and several tills are exposed in bluffs along Lake Ontario. A large area of till exists on the surface in the north-central part of the town and forms the physiographic region known as the South Slope (Chapman and Putnam 1966, pp. 287-292). The South Slope is a rolling till plain with elevations ranging from 500 to 900 feet (152 to 275 m) a.s.l. Till has little value as aggregate because of its high silt and clay content.

Several ice-contact stratified drift and outwash deposits occur south of the Oak Ridges Moraine. For the most part, the ice-contact deposits are situated along river and creek valleys and consist of sand with minor amounts of gravel. Some ice-contact material is also buried beneath till in ridges south of the

moraine. Outwash deposits cover large areas near the community of Hampton in the west-central part of the town and along the town's eastern boundary near the community of Kendal. These deposits consist largely of sand although accumulations of gravel may be present locally.

During the final stages of ice withdrawal, postglacial Lake Iroquois occupied the Lake Ontario basin. This ancient lake was considerably larger than modern Lake Ontario and covered the southern part of Newcastle. The northernmost position is marked by a wave-cut shoreline which trends across the southern part of the town approximately 3 to 6 miles (5 to 10 km) north of Lake Ontario. The land between the Lake Iroquois shoreline and Lake Ontario is known as the Iroquois Plain (Chapman and Putnam 1966, pp. 324-336). Topographic elevations range from around 250 feet (76 m) at the Lake Ontario shore up to 500 feet (152 m) along the Lake Iroquois shoreline. In the deeper waters of Lake Iroquois, silt and clay were deposited. Lacustrine plain sediments of silty fine to coarse sand were deposited in the shallower parts of the lake. Shoreline wave action resulted in lacustrine beaches being developed. The beach deposits, consisting of well stratified, coarse sand and gravel, have been a significant source of quality aggregate.

EXTRACTIVE ACTIVITY

Numerous pits have been opened in the Town of Newcastle. The majority are located in the Lake Iroquois beach deposits in the southern part of the town and in the Oak Ridges Moraine along the town's northern boundary. Many of the pits have become inactive since the designation of the former townships of Darlington and Clarke in 1973 under The Pits and Quarries Control Act, 1971. At the time of writing, twenty-eight pits were licenced to operate. The total licenced area of these sources is 1893.0 acres (766.1 ha). The average annual production from pits in the seven-year period between 1976 and 1982 has been 530,889 tons (481 622 tonnes).

In the past, extractive activity was largely concentrated in the Lake Iroquois beach deposits. Ten licenced pits along with thirteen identified unlicenced pits have been developed in the beach deposits. A considerable volume of aggregate has been removed from these pits and many of the pits are currently depleted or are near depletion.

Present aggregate extraction is largely centered in the Oak Ridges Moraine which remains a relatively large, undeveloped area in the northern part of the town. Over the last six years, aggregate production in the moraine has averaged more than double that produced from the Lake Iroquois beach deposits. Fifteen properties have been licenced for extraction in the moraine and five of these pits have a "moderate to high" use rating according to criteria established by the Ontario Ministry of Transportation and Communications (Deike 1981). Pits with moderate to high ratings are able to produce Granular Base Course (G.B.C.) A and Hot-Laid (H.L.) No. 4 stone.

One quarry with an area of 597.3 acres (241.7 ha) has also been licenced to operate. The quarry and cement plant of the St. Marys Cement Company are located southwest of Bowmanville. Four benches are worked in the quarry (Narain 1983). The uppermost bench consists of up to 18 feet (5 m) of Whitby Formation shale. Underlying this are three 50-foot (15 m) benches of Lindsay Formation limestone. The high calcium carbonate content of the second lowest bench requires shale or low carbonate limestone from the lowest bench to dilute it. The rock extracted from the quarry forms the raw material from which cement clinker is produced. The clinker is then either used to produce cement on the site or shipped to some of the company's plants in the United States. Approximately 1.1 million tons (1.0 million tonnes) are presently being extracted annually from the quarry (Narain 1983).

SELECTED SAND AND GRAVEL RESOURCE AREAS

The sand and gravel deposits selected for possible resource protection in the Town of Newcastle are shown on Map 2. An area in the Oak Ridges Moraine and three beach deposits have been selected as Sand and Gravel Resource Areas of Primary Significance. In addition, a number of deposits have been selected as Sand and Gravel Resource Areas of Secondary Significance.

The Selected Sand and Gravel Resource Areas of Primary Significance have a total of 8700 acres (3500 ha) potentially available for extraction, containing possible sand and gravel re-

sources of approximately 640 million tons (580 million tonnes). The available portions of the selected areas represent 14 percent of the total area of sand and gravel deposits in Newcastle, and 16 percent of the original tonnage.

SELECTED SAND AND GRAVEL RESOURCE AREA 1

Selected Sand and Gravel Resource Area 1 is located along the northern boundary of the town in the Oak Ridges Moraine. The geological boundary for Area 1 is somewhat generalized because of the limited amount of subsurface data. However, Area 1 is considered to have generally greater potential for further development than the surrounding morainic deposits on the basis of two factors. First, as shown by the concentration of existing pits, the area is a traditional aggregate source, in contrast to the rest of the moraine which remains relatively undeveloped. Second, pit exposures as well as other subsurface data, indicate a greater proportion of coarse granular material in Area 1 than in the surrounding deposit.

Deike (1981) reports that the gravel within the moraine is usually of high petrographic quality. However, the general lack of crushable gravel and the variability of the material restrict the overall quality of the aggregate and often necessitate selective extraction and sand control for crushing. Silt and minor amounts of incorporated till are present in some of the pits. Selective extraction procedures are also required where these materials are present.

In Area 1, eight pits are currently licenced to operate under The Pits and Quarries Control Act, 1971. Five unlicenced pits have also been identified in the Area. The faces in these pits range from 5 to 50 feet (1.5 to 15 m) high and generally expose well sorted and stratified sand and gravel. Several of these pits contain coarse aggregate suitable for uses such as hot-laid asphalt, structural concrete and G.B.C. A (Deike 1981). The remaining pits contain predominantly sandy aggregate acceptable for G.B.C. B and C, along with subgrade material. In most of the sources the sand fraction of the aggregate requires blending for hot-laid asphalt. A sample from pit no. 9 revealed 55 percent gravel (Figure 2a).

Resource Area 1 occupies 7100 acres (2850 ha), exclusive of licenced properties. Cultural constraints and previous extraction reduce the area potentially available for extraction to 6300 acres (2550 ha). Assuming an average deposit thickness of 35 feet (11 m), available sand and gravel resources are estimated to be 550 million tons (500 million tonnes).

SELECTED SAND AND GRAVEL RESOURCE AREA 2

Selected Sand and Gravel Resource Area 2 consists of three Lake Iroquois beach deposits labelled 2a to 2c on Map 2. The deposits are located in the south-central part of the town and have been a traditional source of aggregate. The beach deposits usually consist of well stratified coarse sand and gravel.

Several pits in these deposits have been tested by the Ontario Ministry of Transportation and Communications and the results indicate that the aggregate is generally of similar quality to that in the Oak Ridges Moraine (Deike 1981). The most evident difference is that the gravel in the beaches tends to have a slightly lower percentage of crushable material. Similar to the moraine, the beach deposits have a variable gravel content and some pits contain silt seams. Selective extraction and sand control are also required for crushing.

Area 2a is the least developed of the selected beach deposits. Three unlicenced pits have been identified in the Area with faces ranging in height from 5 to 15 feet (1.5 to 5 m). The aggregate extracted from the pits has been used for most types of granular base course as well as asphaltic stone.

Four licenced pits and three identified unlicenced sources have been developed in Area 2b. The aggregate from these pits is suitable for a range of uses. Such products as G.B.C. A and H.L. 4 stone have been produced from pockets of crushable gravel present in a number of the sources. A considerable amount of the aggregate, however, is of a sandy nature and suitable for G.B.C. B and C, as well as subgrade uses. A sample from pit no. 25 revealed 29 percent gravel (Figure 2a).

Area 2c is the most highly developed of the beach deposits with respect to both extractive and cultural development. Five licenced pits and two identified unlicenced pits are present in the Area. Faces in the pits expose between 5 and 30 feet (1.5 and 9 m) of sandy aggregate. The most readily produced products from these pits

include G.B.C. B and C, and select subgrade material. A small number of the pits contain pockets of gravel suitable for crushing.

Even though the beach deposits are considered a source of quality aggregate, a considerable amount of the area occupied by the deposits is unavailable for extraction because of residential and other permanent development, as well as extensive previous extraction of aggregate. Many of the pits are presently depleted or are near depletion. Although pit development has generally been concentrated in areas containing higher gravel contents, the remaining aggregate is considered to be suitable for a range of uses. The deposits are close to local markets and good access is provided by the present road network.

Resource Area 2 occupies 4100 acres (1660 ha). Cultural constraints and previous extraction reduce the area potentially available to 2410 acres (980 ha). Assuming an average deposit thickness of 15 feet (5 m) for Areas 2a, 2b and 2c, available sand and gravel resources are estimated to total 90 million tons (82 million tonnes).

SAND AND GRAVEL RESOURCE AREAS OF SECONDARY SIGNIFICANCE

A considerable area of the Oak Ridges Moraine in the northern part of Newcastle has been selected as a Sand and Gravel Resource Area of Secondary Significance. The resources in this part of the moraine are relatively unexploited. There are, however, seven licenced pits with faces exposing up to 80 feet (24 m) of generally sandy aggregate suitable for use as G.B.C. B and C as well as select subgrade material. The sand fraction of the aggregate from pits in this deposit requires blending for asphaltic sand use and a small number of the pits contain pockets of crushable material. A sample taken from pit no. 2 revealed 4 percent gravel and 68 percent sand (Figure 2a). The predominance of sand at the surface and a variable gravel content make exploration for concentrations of gravel difficult. Future exploration may uncover more gravel and further increase the resource potential of the deposit.

Two ice-contact deposits, one located south of the moraine near Leskard and the other west of Kendal, have also been selected as Resource Areas of Secondary Significance. They are generally sand sources, although concentrations of gravel may be present locally. A sample taken from the deposit situated west of Leskard, at described section NE-DS-1, revealed 14 percent gravel (Figure 2a).

Further investigation of the South Slope area in Newcastle may reveal additional gravel resources, especially in the northern part, near the moraine. Gwyn (1976) reports that a considerable amount of aggregate may be buried beneath till in this area.

BEDROCK GEOLOGY

The Town of Newcastle is underlain by Upper Ordovician limestone of the Lindsay Formation and shale of the Whitby Formation. The geological boundary between these formations is shown on Map 3. The boundary follows that outlined by Liberty (1969) with the exception of the area near Bowmanville where the boundary has been revised on the basis of data provided by Ontario Hydro (J. Grass, Geotechnical Engineer, Ontario Hydro, Toronto, personal communication, 1982).

Both the Lindsay and Whitby strata are exposed southwest of Bowmanville in the St. Marys Cement quarry. With the exception of an area in the south-central part of Newcastle, most of the town is thickly drift covered. The thickness of overburden increases northwards with the greatest depth occurring in the Oak Ridges Moraine.

The Lindsay Formation consists of grey, sublithographic to fine-grained, nodular limestone (Carson 1980). The formation is thin to medium bedded, containing common shaly partings. A drillhole placed by Ontario Hydro at the Darlington Nuclear Power site showed this formation to be 207 feet (63 m) thick.

The Whitby shale overlies the Lindsay strata in the western part of the town. At the base of the formation the shale is black, fissile, highly petroliferous and calcareous (Liberty 1969). It is overlain by brown, slightly petroliferous and slightly calcareous shale. The thickness of the Whitby shale in the Town of Newcastle has not been determined. However, drillholes placed in the Pickering area by the Engineering and Terrain Geology Section of the Ontario Geological Survey indicate that the lower black shale unit is about 15 feet (5 m) thick (Johnson

1983). Liberty (1969) reports the total thickness of the formation to be 290 feet (88 m) in the Toronto area.

The Lindsay Formation and part of the lower black shale unit of the Whitby Formation are being quarried for use as a raw material for cement production at the St. Marys' Bowmanville quarry, but have little value as crushed stone resources. The Whitby shale is too soft for crushing and the Lindsay strata contain numerous clayey partings which make it unsatisfactory for use as crushed concrete aggregate and many less demanding uses (Dolar-Mantuani 1975). Even though the Lindsay Formation is a valuable resource material for cement production, it has not been selected for resource protection because it is usually covered by more than 25 feet (8 m) of drift.

SUMMARY

The sand and gravel deposits of the Town of Newcastle are the product of glacial activity which occurred during the Late Wisconsinan. Two areas containing significant amounts of sand and gravel have been selected as Sand and Gravel Resource Areas of Primary Significance. In addition, three deposits have been selected at the secondary level of significance. The town has resources of sand and gravel which should be sufficient to meet local needs for a considerable period of time. However, possible resources of crushable gravel are limited. Although several deposits have been selected for resource protection at the primary and secondary levels, careful management is necessary to preserve as much of the remaining resources as possible.

The town is underlain by the Ordovician limestone of the Lindsay Formation and shale of the Whitby Formation. The Lindsay strata are suitable for use as a raw material in cement manufacture, but have not been selected for resource protection because of the considerable thickness of overlying drift.

Enquires regarding the Aggregate Resources Inventory of the Town of Newcastle should be directed to the Ontario Ministry of Natural Resources either at the Lindsay District Office, 322 Kent Street West, Lindsay, Ontario, K9V 4T7 (Tel. (705) 324-6121) or at the Central Region Office, 10670 Yonge Street, Richmond Hill, Ontario, L4C 3C9 (Tel. (416) 884-9203).

TABLE 1 | TOTAL SAND AND GRAVEL RESOURCES, TOWN OF NEWCASTLE*

1 CLASS NO.	2 DEPOSIT TYPE (see Appendix C)	3 AREAL EXTENT Acres (Hectares)	4 ORIGINAL TONNAGE Millions of Tons (Tonnes)
1	G-IC	7600 (3100)	660 (600)
	S-IC	17,600 (7100)	1510 (1370)
	S-LP	17,400 (7000)	920 (840)
	S-OW	4500 (1820)	390 (355)
2	G-IC	43 (17)	2 (2)
	S-IC	1720 (700)	75 (68)
	G-LB	325 (132)	12 (11)
	S-LB	5700 (2310)	206 (187)
	S-LP	130 (53)	4 (4)
	S-OW	7800 (3150)	230 (209)
3	S-IC	160 (65)	3 (3)
	S-LB	14 (6)	1 (1)
	S-LP	920 (370)	16 (14)
		64,000 (26 000)	4050 (3650)

* Identified deposit areas within Orono Provincial Forestry Station are omitted on all tables.

N.B. Minor variations in tables are caused by rounding of data.

TABLE 2 | SAND AND GRAVEL PITS, TOWN OF NEWCASTLE

1 NO.	2 MTC NO.	3 OWNER/OPERATOR	4 LOT	5 CON.	6 LICENCED AREAS Acres (Hectares)	7 FACE HEIGHT Feet (Metres)	8 % GRAVEL
LICENCED PITS							
1	S02-163	H. Ambrose	Pt. 31	9, 10	203.0 (82.2)	10-20 (3-6)	<10 partially overgrown
2	S02-134	Highland Creek Sand & Gravel Co. Ltd.	Pt. 14, 15, 16, 17	10	347.0 (140.4)	10-30 (3-9)	<20 partially overgrown
3	S02-108	Tripp Construction Ltd.	S½ 12	9	50.0 (20.2)	30-70 (9-21)	20-40 variable
4		Gerald M. Balson & Sons	Pt. 7	9	5.4 (2.2)	10 (3)	<20
5	S02-133	G. Kovacs	Pt. 6	9	50.0 (20.2)	20-40 (6-12)	<10
6	S02-087	G. Kovacs	Pt. 2	9	52.0 (21.0)	30-50 (9-15)	30-40
7	S02-096	Keystone Sand & Gravel Inc.	Pt. 2	8	27.3 (11.0)	10-15 (3-5)	30-40 partially overgrown
8		518824 Ontario Ltd.	32	10	66.6 (27.0)	5-10 (1.5-3)	<10
9	S02-050	Bennett Paving & Materials Ltd.	Pt. 27, 28	10	76.0 (30.8)	20-40 (6-12)	40-50 partially overgrown
10	S02-082	Beatty Haulage Ltd.	Pt. 27, 28	10	48.1 (19.5)	10-30 (3-9)	20
11	S02-149	TRT Industries Ltd.	Pt. 25, 26	10	75.0 (30.4)	unopened	
12	S02-150	Standard Aggregates, A Division of Standard Industries Ltd.	Pt. 18	10	70.0 (28.3)	5-25 (1.5-8)	40-50 partially overgrown
13	S02-012	Harnden & King Construction Ltd.	17	10	82.0 (33.2)	20-40 (6-12)	30-40 partially overgrown

TABLE 2 | SAND AND GRAVEL PITS, TOWN OF NEWCASTLE

1 NO.	2 MTC NO.	3 OWNER/OPERATOR	4 LOT	5 CON.	6 LICENCED AREAS Acres (Hectares)	7 FACE HEIGHT Feet (Metres)	8 % GRAVEL
14	S02-036	518824 Ontario Ltd.	Pt. 32	8	104.2 (42.2)	50-80 (15-24)	<10
15	S02-028	Bennett Paving & Materials Ltd.	Pt. 33	7	18.0 (7.3)	30-40 (9-12)	<10 partially overgrown
16		J.A. Sutherland	Pt. 27, 28	7	4.8 (1.9)	10-20 (3-6)	20 partially overgrown
17	S02-057	W. Reid	Pt. 8	7	26.2 (10.6)	20-25 (6-8)	<20 partially overgrown
18	004-041	R. Beatty	Pt. 29	4	10.0 (4.0)	10 (3)	<10 partially overgrown
19	004-012	Harnden & King Construction Ltd.	Pt. 23	3	29.4 (11.9)	5-10 (1.5-3)	<10
20	004-015	TRT Industries Ltd.	Pt. 18	3	75.0 (30.4)	10-15 (3-5)	<20 partially rehabilitated
21	004-019	Harnden & King Construction Ltd.	Pt. 13, 14	3	75.0 (30.4)	marshalling area	
22	004-044	J.L. Coombes	Pt. 6	4	25.6 (10.4)	20-30 (6-9)	<20 partially overgrown
23		J.S. Harmer	Pt. 6	4	34.2 (13.8)	20-30 (6-9)	<20
24		TRT Industries Ltd.	Pt. 5	4	100.0 (40.5)	unopened	
25	004-087	Corp. of the Town of Newcastle	Pt. 16	2	90.0 (36.4)	10-15 (3-5)	20-30 partially overgrown
26	004-039 004-026 004-102 004-082	Ridgeland Holdings Ltd.	Pt. 16	2	96.0 (38.8)	10-15 (3-5)	20 partially overgrown

TABLE 2 | SAND AND GRAVEL PITS, TOWN OF NEWCASTLE

1 NO.	2 MTC NO.	3 OWNER/OPERATOR	4 LOT	5 CON.	6 LICENCED AREAS Acres (Hectares)	7 FACE HEIGHT Feet (Metres)	8 % GRAVEL
27	004-085	G. Tantsidis, J. Tantsidis, L. Nunno	E½ 15	2	42.0 (17.0)	5-15 (1.5-5)	20-30 partially overgrown
28		C. Farrow	Pt. 13	1	10.2 (4.1)	10-15 (3-5)	20-30 partially overgrown
					1893.0 (766.1)		
UNLICENCED PITS*							
29	S02-089	Simms	3	9		10-15 (3-5)	30-40
30		Unknown	4	8		12 (4)	30-40
31	S02-159	Syers	32	9		12 (4)	30-40 overgrown
32	S02-022	Timoll	29, 30	10		15-20 (5-6)	30-40 partially overgrown
33	S02-154	Cochrane	25	9		10 (3)	35-40 partially overgrown
34	S02-013	Lycett	24	9		12 (4)	25 partially overgrown
35	S02-055	Carson	8	6		5-10 (1.5-3)	10-20
36	004-061	General Agg. Ltd. W. Bennett	33	6		10-15 (3-5)	30-40 largely depleted
37	004-104	Bennett	33	6		30 (9)	10
38	004-034	Dutch Sand & Gravel	29	4		15 (5)	overgrown
39	004-048	Petry Shyn # 2	29	3		5-10 (1.5-3)	overgrown

TABLE 2 | SAND AND GRAVEL PITS, TOWN OF NEWCASTLE

1 NO.	2 MTC NO.	3 OWNER/OPERATOR	4 LOT	5 CON.	6 LICENCED AREAS Acres *(Hectares)*	7 FACE HEIGHT Feet *(Metres)*	8 % GRAVEL
40	004-014	Snowden	21	3		10 (3)	water filled
41	004-008	N. Fice	17	3		10-12 (3-4)	20 partially overgrown
42	004-076	Tripp Construction	1, 2	4		20-30 (6-9)	20
43	004-020	Kovacs	1	4		10-12 (3-4)	20
44	004-078	Graham	20	3		5 (1.5)	depleted & overgrown
45	004-079	Edwards	16	3		10-15 (3-5)	30-45 largely depleted
46	004-080	Heatly	13, 14	3		10-15 (3-5)	20-30
47	004-024	Hale	11, 12	3		presently a dump site	
48	004-092	Reid	15	3		8 (2)	10-20
49	004-069	C. Farrow (Stapleton)	12, 13	1		15 (5)	20-30 water filled
50	004-071	Ovens	12	1		10-15 (3-5)	20 partially overgrown

* Abandoned pits or wayside pits operating on demand under authority of a permit.

TABLE 3 SELECTED SAND AND GRAVEL RESOURCE AREAS, TOWN OF NEWCASTLE

1 DEPOSIT NO.	2 UNLICENCED AREA Acres (Hectares)	3 CULTURAL SETBACKS Acres (Hectares)	4 EXTRACTED AREA Acres (Hectares)	5 AVAILABLE AREA Acres (Hectares)	6 ESTIMATED DEPOSIT THICKNESS Feet (Metres)	7 AVAILABLE AGGREGATE Millions of Tons (Tonnes)
1	7100 (2850)	780 (315)	20 (8)	6300 (2550)	35 (11)	550 (500)
2a	1140 (460)	280 (113)	30 (12)	830 (335)	15 (5)	31 (28)
2b	1080 (435)	370 (150)	60 (24)	650 (265)	15 (5)	24 (22)
2c	1860 (750)	860 (350)	70 (28)	930 (375)	15 (5)	35 (32)
	4100 (1660)	1510 (610)	160 (65)	2410 (980)		90 (82)
	11,200 (4550)	2290 (930)	180 (73)	8700 (3500)		640 (580)

TABLE 4 | TOTAL IDENTIFIED BEDROCK RESOURCES, TOWN OF NEWCASTLE

1 **DRIFT THICKNESS** Feet (Metres)	2 **FORMATION**	3 **ESTIMATED DEPOSIT THICKNESS** Feet (Metres)	4 **AREAL EXTENT** Acres (Hectares)	5 **ORIGINAL TONNAGE** Millions of Tons (Tonnes)
25-50 (8-15)	Whitby	15* (5)	1470 (600)	70 (64)
25-50 (8-15)	Lindsay	60 (18)	3750 (1520)	810 (740)
			5200 (2100)	880 (800)

* The deposit thickness of the Whitby Formation has been estimated to average 15 feet (5 m) in the vicinity of Bowmanville because of the proximity of the contact between the Lindsay and Whitby strata.

TABLE 5 | QUARRIES, TOWN OF NEWCASTLE

1 NO.	2 MTC NO.	3 OWNER/OPERATOR	4 LOT	5 CON.	6 LICENCED AREA Acres (Hectares)	7 FACE HEIGHT Feet (Metres)
1	004-001	St. Marys Cement Company Ltd.	12, 13, 14, 15, 16, 17	B.F.C.	597.3 (241.7)	160-168 (49-51)

TABLE 6 | SELECTED BEDROCK RESOURCE AREAS, TOWN OF NEWCASTLE

1 **DEPOSIT NO.**	2 **DEPTH OF OVERBURDEN** Feet (Metres)	3 **UNLICENCED AREA** Acres (Hectares)	4 **CULTURAL SETBACKS** Acres (Hectares)	5 **EXTRACTED AREA** Acres (Hectares)	6 **AVAILABLE AREA** Acres (Hectares)	7 **ESTIMATED WORKABLE THICKNESS** Feet (Metres)	8 **AVAILABLE RESOURCES** Millions of Tons (Tonnes)

– NONE –

TABLE 7 | SUMMARY OF TEST HOLE DATA, TOWN OF NEWCASTLE

– NONE –

TABLE 8 | DESCRIBED SECTIONS, TOWN OF NEWCASTLE

Described Section Number: NE-DS-1

Location: Conc. 8, Lot 35

Elevation: 770 feet (235 m) a.s.l.

DEPTH feet (metres)	DESCRIPTION
20 (6)	largely clean, well stratified medium sand with minor amounts of fine gravel

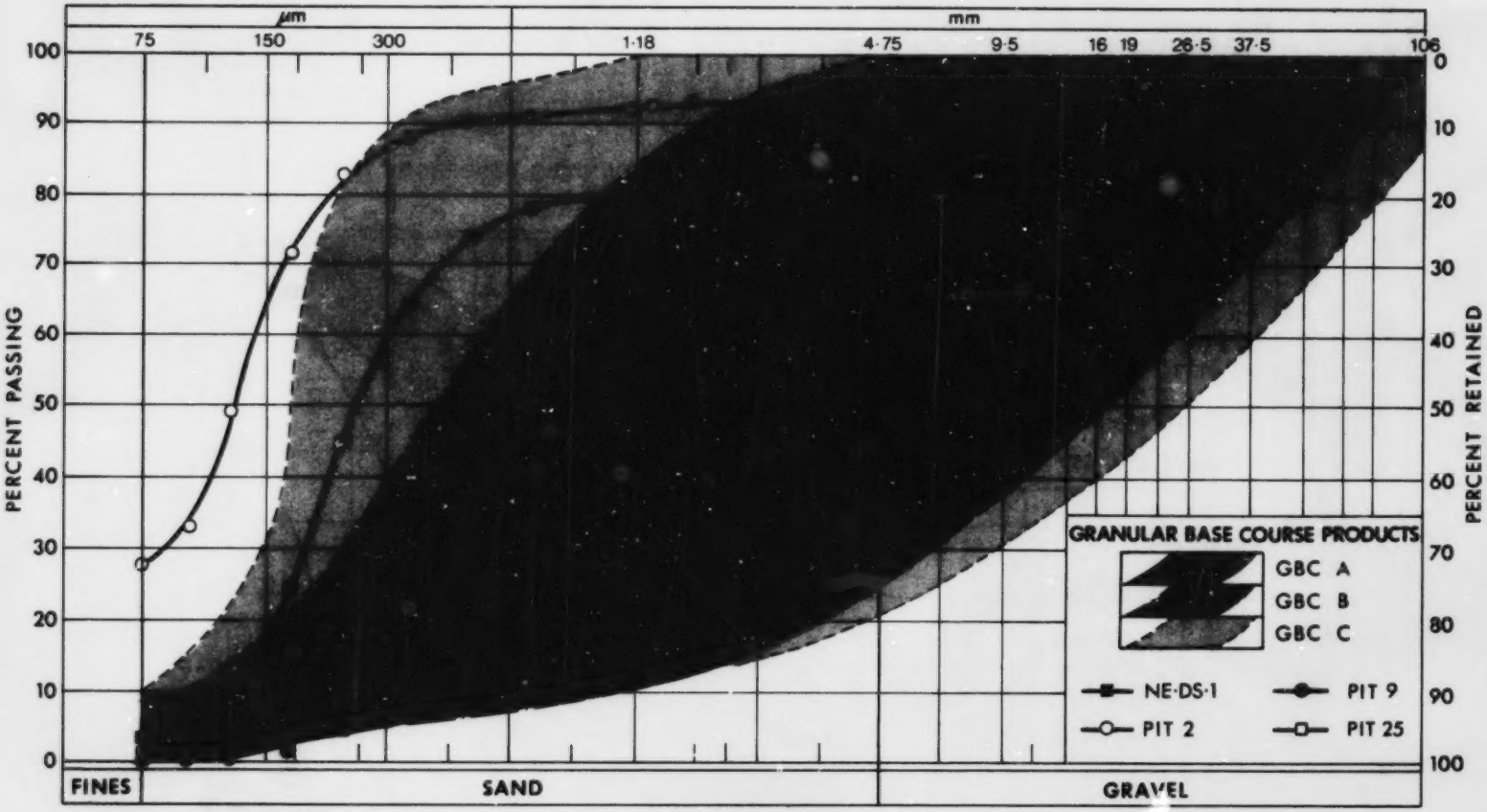


FIGURE 2a: AGGREGATE GRADING CURVES, TOWN OF NEWCASTLE;

Based on analysis of the total aggregate contained in unprocessed samples (gradation envelopes adapted from M.T.C. Form 1010, 1980).

NOTE: Information portrayed by grading curves refers strictly to a specific sample taken at the time of field investigation. Due to the inherent variability of sand and gravel deposits care should be exercised in extrapolating such information to the rest of the deposit.

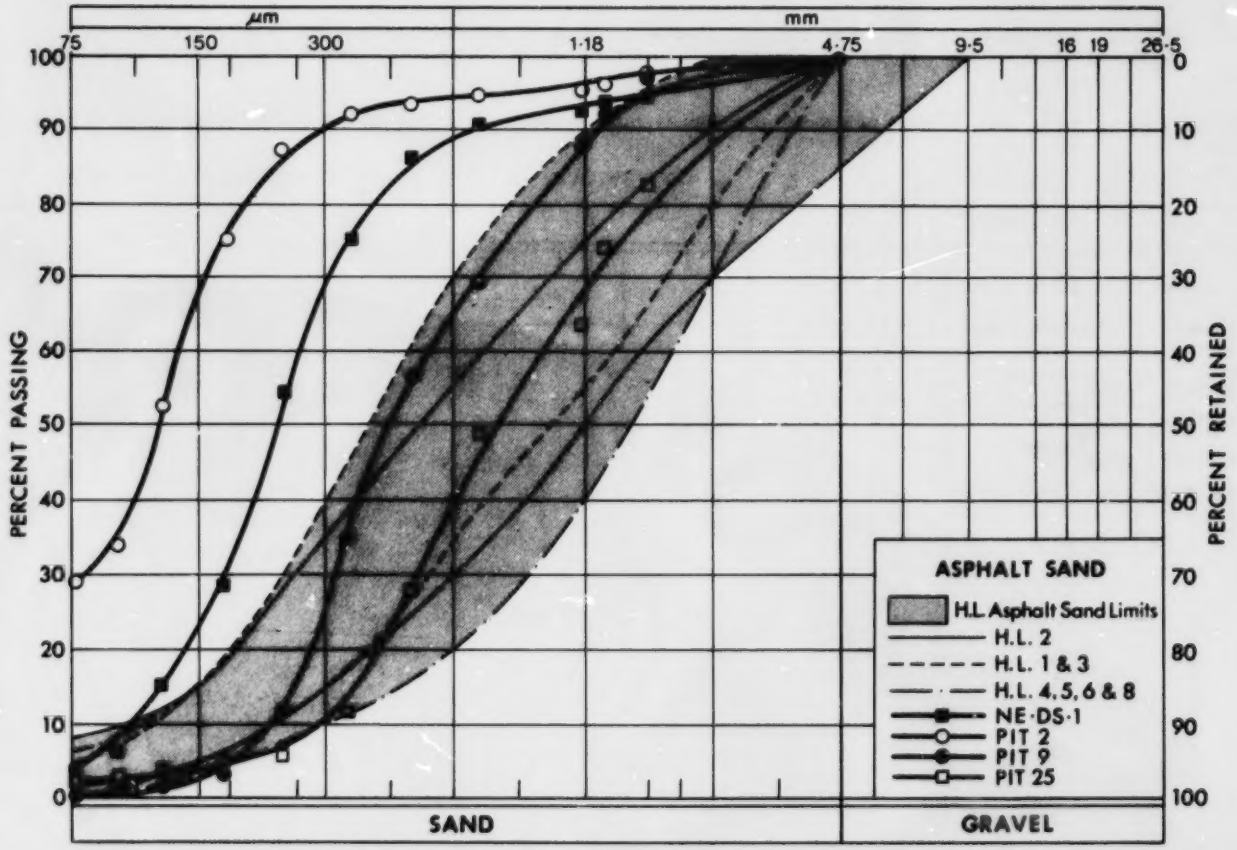


FIGURE 2b: AGGREGATE GRADING CURVES, TOWN OF NEWCASTLE;

Based on analysis of the sand fraction of the aggregate contained in unprocessed samples (gradation envelopes adapted from M.T.C. Form 1003, 1979).

NOTE:

Information portrayed by grading curves refers strictly to a specific sample taken at the time of field investigation. Due to the inherent variability of sand and gravel deposits care should be exercised in extrapolating such information to the rest of the deposit.

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APPENDIX B - GLOSSARY

ABRASION RESISTANCE

Tests such as the Los Angeles Abrasion Test are used to measure the ability of aggregate to resist crushing and pulverizing under conditions similar to those encountered in processing and use. Measuring resistance is an important component in the evaluation of the quality and prospective uses of aggregate. Hard, durable material is preferred for road building.

ABSORPTION CAPACITY

Related to the porosity of the rock types of which an aggregate is composed. Porous rocks are subject to disintegration when absorbed liquids freeze and thaw, thus decreasing the strength of the aggregate.

AGGREGATE

Any hard, inert, construction material (sand, gravel, shells, slag, crushed stone or other mineral material) used for mixing in various-sized fragments with a cement or bituminous material to form concrete, mortar, etc., or used alone for road building or other construction. Synonyms include mineral aggregate and granular material.

ALKALI-AGGREGATE REACTION

A chemical reaction between the alkalies of portland cement and certain minerals found in rocks used for aggregate. Alkali-aggregate reactions are undesirable because they can cause expansion and cracking of concrete. Although perfectly suitable for building stone and asphalt applications, alkali-reactive aggregates should be avoided for structural concrete uses.

BLENDING

Required in cases of extreme coarseness, fineness or other irregularities in the gradation of unprocessed aggregate. Blending is done with approved sand-sized aggregate in order to satisfy the gradation requirements of the material.

CAMBRIAN

The first period of the Paleozoic Era, thought to have covered the time between 570 and 500 million years ago; the Cambrian precedes the Ordovician Period.

CLAST

An individual constituent, grain or fragment of a sediment or rock, produced by the mechanical weathering of a larger rock mass. Synonyms include particle and fragment.

CRUSHABLE AGGREGATE

Unprocessed gravel containing a minimum of 35 percent coarse aggregate larger than the No. 4 sieve (4.75 mm) as well as a minimum of 20 percent greater than the 26.5 mm sieve.

DELETERIOUS LITHOLOGY

A general term used to designate those rock types which are chemically or physically unsuited for use as construction or road-building aggregates. Such lithologies as chert, shale, siltstone and sandstone may deteriorate rapidly when exposed to traffic and other environmental conditions.

DEVONIAN

A period of the geological past thought to have covered the span of time between 395 and 345 million years ago, following the Silurian Period. Rocks formed in the Devonian Period are among the youngest found in Ontario.

DOLOSTONE

A carbonate sedimentary rock consisting chiefly of the mineral dolomite and containing relatively little calcite (dolostone is also known as dolomite).

DRIFT

A general term for all unconsolidated rock debris transported from one place and deposited

in another; distinguished from underlying bedrock. In North America, glacial activity has been the dominant mode of transport and deposition of drift. Synonyms include overburden and surficial deposit.

DRUMLIN

A low, smoothly rounded, elongated hill, mound, or ridge composed of glacial materials. These landforms were deposited beneath an advancing ice sheet, and were shaped by its flow.

EOLIAN

Pertaining to the wind, especially with respect to landforms whose constituents were transported and deposited by wind activity. Sand dunes are an example of an eolian landform.

FINES

A general term used to describe the size fraction of an aggregate which passes (is finer than) the No. 200 mesh screen (.075 mm). Also described informally as "dirt", these particles are in the silt and clay size range.

GLACIAL LOBE

A tongue-like projection from the margin of the main mass of an ice cap or ice sheet. During the Pleistocene Epoch several lobes of the Laurentide continental ice sheet occupied the Great Lakes basins. These lobes advanced and retreated numerous times during the Pleistocene, producing the complex arrangement of glacial material and landforms found in southern Ontario.

GRADATION

The proportion of material of each particle size, or the frequency distribution of the various sizes which constitute a sediment. The strength, durability, permeability and stability of an aggregate depend to a great extent on its gradation. The size limits for different particles are as follows:

Boulder	more than 200 mm
Cobbles	75-200 mm
Coarse Gravel	26.5-75 mm
Fine Gravel	4.75-26.5 mm
Coarse Sand	2-4.75 mm
Medium Sand	0.425-2 mm
Fine Sand	0.075-0.425 mm
Silt, Clay	less than 0.075 mm

GRANULAR BASE COURSE

Components of the pavement structure of a road, which are placed on the subgrade and are designed to provide strength, stability and drainage, as well as support for surfacing materials. Several types have been defined: Granular Base Course A consists of crushed and processed aggregate and has relatively stringent quality standards in comparison to Granular Base Course B and C which are usually pit-run or other unprocessed aggregate.

HOT-LAID (OR ASPHALTIC) AGGREGATE

Bituminous, cemented aggregates used in the construction of pavements either as surface or bearing course (H.L. 1, 3 and 4), or as binder course (H.L. 2, 6 and 8) used to bind the surface course to the underlying granular base course.

LITHOLOGY

The description of rocks on the basis of such characteristics as color, structure, mineralogic composition and grain size. Generally, the description of the physical character of a rock.

MELTWATER CHANNEL

A drainage way, often terraced, produced by water flowing away from a melting glacier margin.

ORDOVICIAN

An early period of the Paleozoic Era thought to have covered the span of time between 500 and 435 million years ago.

PALEOZOIC ERA

One of the major divisions of the geologic time scale thought to have covered the time between 570 and 230 million years ago, the Paleozoic Era (or Ancient Life Era) is subdivided into six geologic periods, of which only four (Cambrian, Ordovician, Silurian and Devonian) can be recognized in southern Ontario.

PETROGRAPHIC EXAMINATION

An aggregate quality test based on known field performance of various rock types. The test result is a Petrographic Number (P.N.). The higher the P.N. the lower the quality of the aggregate.

PLEISTOCENE

An Epoch of the recent geological past including the time from approximately 1.8 million years ago to 7000 years ago. Much of the Pleistocene was characterized by extensive glacial activity and is popularly referred to as the "Great Ice Age".

POSSIBLE RESOURCE

Reserve estimates based largely on broad knowledge of the geological character of the deposit and for which there are few, if any samples or measurements. The estimates are based on assumed continuity or repetition for which there are reasonable geological indications.

SHALE

A fine-grained, sedimentary rock formed by the consolidation of clay, silt or mud and characterized by well developed bedding planes, along which the rock breaks readily into thin layers. The term shale is also commonly used for fissile claystone, siltstone and mudstone.

SILURIAN

An early period of the Paleozoic Era thought to have covered the time between 435 and 395 million years ago. The Silurian follows the Ordovician Period and precedes the Devonian Period.

SOUNDNESS

The ability of the components of an aggregate to withstand the effects of various weathering processes and agents. Unsound lithologies are subject to disintegration caused by the expansion of absorbed solutions. This may seriously impair the performance of road-building and construction aggregates.

TILL

Unsorted and unstratified rock debris, deposited directly by glaciers, and ranging in size from clay to large boulders.

WISCONSINAN

Pertaining to the last glacial period of the Pleistocene Epoch in North America. The Wisconsinan began approximately 100 000 years ago and ended approximately 7000 years ago. The glacial deposits and landforms of southern Ontario are predominantly the result of glacial activity during the Wisconsinan Stage.

APPENDIX C - GEOLOGY OF SAND AND GRAVEL DEPOSITS

The type, distribution, and extent of sand and gravel deposits in southern Ontario are the result of extensive glacial and glacially influenced activity in Wisconsinan time during the Pleistocene Epoch, approximately 100 000 to 7000 years ago. The deposit types reflect the different depositional environments that existed during the melting and retreat of the continental ice masses, and can readily be differentiated on the basis of their morphology, structure, and texture. The deposit types are described below.

GLACIOFLUVIAL DEPOSITS

These deposits can be divided into two broad categories: those that were formed in contact with (or in close proximity to) glacial ice, and those that were deposited by meltwaters carrying materials beyond the ice margin.

ICE-CONTACT TERRACES (ICT)

These are glaciofluvial features deposited between the glacial margin and a confining topographic high, such as the side of a valley. The structure of the deposits may be similar to that of outwash deposits, but in most cases the sorting and grading of the material is more variable and the bedding is discontinuous due to extensive slumping. The probability of locating large amounts of crushable aggregate is moderate, and extraction may be expensive due to the variability of the deposits both in terms of quality and grain size distribution.

KAMES (K)

Kames are defined as mounds of poorly sorted sand and gravel deposited by meltwater in depressions or fissures on the ice surface or at its margin. During glacial retreat, the melting of supporting ice causes collapse of the deposits producing internal structures characterized by bedding discontinuities. The deposits consist mainly of irregularly bedded and crossbedded, poorly sorted sand and gravel. The present forms of the deposits include single mounds, linear ridges (crevasse fillings) or complex groups of landforms. The latter are occasionally described as "undifferentiated ice-contact stratified drift" (IC) when detailed subsurface information is unavailable. Since kames commonly contain large amounts of fine-grained material and are characterized by considerable variability, there is generally a low to moderate probability of discovering large amounts of good-quality, crushable aggregate. Extractive problems encountered in these deposits are mainly the excessive variability of the aggregate and the rare presence of excess fines (silt- and clay-sized particles).

ESKERS (E)

Eskers are narrow, sinuous ridges of sand and gravel deposited by meltwaters flowing in tunnels within or at the base of glaciers, or in channels on the ice surface. Eskers vary greatly in size. Many, though not all eskers consist of a central core of poorly sorted and stratified gravel characterized by a wide range in grain size. The core material is often draped on its flanks by better sorted and stratified sand and gravel. The deposits have a high probability of containing a large proportion of crushable aggregate, and since they are generally built above the surrounding ground surface, are convenient extraction sites. For these reasons esker deposits have been traditional aggregate sources throughout southern Ontario, and are significant components of the total resources of many areas.

Some planning constraints and opportunities are inherent in the nature of the deposits. Because of their linear nature, the deposits commonly extend across several property boundaries leading to unorganized extractive development at numerous small pits. On the other hand, because of their form, eskers can be easily and inexpensively extracted and are amenable to rehabilitation and sequential land use.

UNDIFFERENTIATED ICE-CONTACT STRATIFIED DRIFT (IC)

This designation may include deposits from several ice-contact, depositional environments which usually form extensive, complex landforms. It is not feasible to identify individual areas of coarse-grained material within such deposits due to their lack of continuity and grain size variability. They are given a qualitative rating based on existing pit and other subsurface data.

OUTWASH (OW)

Outwash deposits consist of sand and gravel laid down by meltwaters beyond the margin of the ice lobes. The deposits occur as sheets or as terraced valley fills (valley trains) and may be very large in extent and thickness. Well developed outwash deposits have good horizontal bedding and are uniform in grain size distribution. Outwash deposited near the glacier's margin is much more variable in texture and structure. The probability of locating useful crushable aggregates in outwash deposits is moderate to high depending on how much information on size, distribution and thickness is available.

ALLUVIUM (AL)

Alluvium is a general term for clay, silt, sand, gravel, or similar unconsolidated material deposited during postglacial time by a stream as sorted or semi-sorted sediment, on its bed or on its floodplain. The probability of locating large amounts of crushable aggregate in alluvial deposits is low, and it has generally low value due to the presence of excess silt- and clay-sized material. There are few large postglacial alluvium deposits in Ontario.

GLACIOLACUSTRINE DEPOSITS

GLACIOLACUSTRINE BEACH DEPOSITS (LB)

These are relatively narrow, linear features formed by wave action at the shores of glacial lakes that existed at various times during the deglaciation of southern Ontario. Well developed lacustrine beaches are usually less than 20 feet (6 m) thick. The aggregate is well sorted and stratified and sand-sized material commonly predominates. The composition and size distribution of the deposit depends on the nature of the source material. The probability of obtaining crushable aggregate is high when the material is developed from coarse-grained materials such as a stony till, and low when developed from fine-grained materials. Beaches are relatively narrow, linear deposits, so that extractive operations are often numerous and extensive.

GLACIOLACUSTRINE DELTAS (LD)

These features were formed where streams or rivers of glacial meltwater flowed into lakes and deposited their suspended sediment. In southern Ontario such deposits tend to consist mainly of sand and abundant silt. However, in near-ice and ice-contact positions, coarse material may be present. Although deltaic deposits may be large, the probability of obtaining coarse material is generally low.

GLACIOLACUSTRINE PLAINS (LP)

The nearly level surface marking the floor of an extinct glacial lake. The sediments which form the plain are predominantly fine to medium sand, silt, and clay, and were deposited in relatively deep water. Lacustrine deposits are generally of low value as aggregate sources due to their fine grain size and lack of crushable material. In some aggregate-poor areas, lacustrine deposits may constitute valuable sources of fill and some granular base course aggregate.

GLACIAL DEPOSITS

END MORAINES (EM)

These are belts of glacial drift deposited at, and parallel to, glacier margins. End moraines commonly consist of ice-contact stratified drift and in such instances are usually called kame moraines. Kame moraines commonly result from deposition between two glacial lobes (interlobate moraines). The probability of locating aggregates within such features is moderate to low. Exploration and development costs are high. Moraines may be very large and contain vast aggregate resources, but the location of the best resource areas within the moraine is usually poorly defined.

EOLIAN DEPOSITS

WINDBLOWN DEPOSITS (WD)

Windblown deposits are those formed by the transport and deposition of sand by winds. The form of the deposits ranges from extensive, thin layers to well developed linear and crescentic ridges known as dunes. Most windblown deposits in southern Ontario are derived from, and deposited on, pre-existing lacustrine sand plain deposits. Windblown sediments almost always consist of fine to coarse sand and are usually well sorted. The probability of locating crushable aggregate in windblown deposits is very low.

APPENDIX D - GEOLOGY OF BEDROCK DEPOSITS

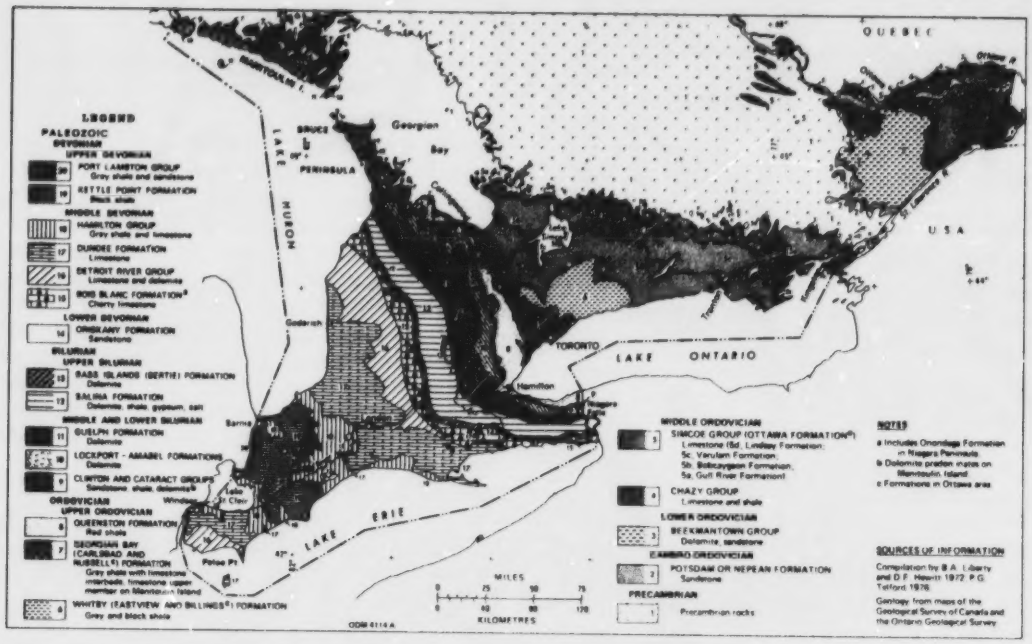

Figure 3 - Bedrock Geology of Southern Ontario

BEDROCK SUITABLE FOR CRUSHED STONE PRODUCTS

BASS ISLANDS FORMATION (UPPER SILURIAN)

(Includes the Bertie Formation of the Niagara Peninsula) Composition: Medium- to massive-bedded, aphanitic, brown dolostone with shaly partings. Thickness: 35 to 60 feet (11 to 18m) near Hagersville. Uses: Quarried for crushed stone on the Niagara Peninsula at Fort Erie, Cayuga, Hagersville, and Dunville. Los Angeles Abrasion Test: 17-35% loss; Absorption: 1.4%. Shaly parts are unsuitable for aggregate due to high soundness losses.

BOBCAYGEON FORMATION (MIDDLE ORDOVICIAN)

Composition: Compact, homogeneous, medium to thin-bedded, fine-grained limestone with some argillaceous and shaly partings. Thickness: The lower unit is 40 to 72 feet (12 to 22 m) thick in the east and the remainder of the formation is 40 feet (12 m). Uses: Quarried at Kirkfield and Marysville for crushed stone. The Bobcaygeon Formation has consistently acceptable quality for granular base course materials and concrete.

BOIS BLANC FORMATION (LOWER-MIDDLE DEVONIAN)

Composition: Brownish grey, medium-crystalline, medium- to thin-bedded, cherty limestone, commonly fossiliferous. Limestone may be silty or sandy in places. Thickness: 9 to 200 feet (3 to 61 m). Uses: Quarried at Hagersville, Cayuga, and Port Colborne for crushed stone. High chert content makes much of the material unsuitable for concrete aggregate. Los Angeles Abrasion Test: 14-28% loss; Soundness Test: 4-10% loss; Absorption: 0.7-2.0%.

DUNDEE FORMATION (MIDDLE DEVONIAN)

Composition: Fine- to medium-crystalline, brownish grey, medium- to thick-bedded, dolomitic limestone with shaly partings, sandy layers, and chert in some areas. Thickness: 60 to 160 feet (18 to 49 m). Uses: Quarried near Port Dover and Pelee Island for crushed stone.

Used at St. Marys for portland cement. Los Angeles Abrasion Test: 22-32% loss; Absorption: 0-4%.

GULL RIVER FORMATION (MIDDLE ORDOVICIAN)

Composition: Member A: thin- to thick-bedded, interbedded, grey argillaceous limestone and buff to green dolostone with a maximum thickness of 60 feet (18 m). Members B and C are dense, aphanitic limestones with argillaceous dolostone interbeds. Uses: Quarried at Kirkfield, Victoria County, and Uhthoff for crushed stone. The product is generally fresh and compact with good cubic-shaped factor, low clay content, low absorption, and low soundness losses. Smooth particle surfaces may cause adhesion problems for asphalt. There is some alkali reactivity in a few of the layers.

LOCKPORT AND AMABEL FORMATIONS (MIDDLE SILURIAN)

Composition: Amabel Formation (Waterdown to the Bruce Peninsula): massive, fine-crystalline dolostone, with reef facies dolostone near Georgetown. Lockport Formation (lateral facies equivalent to the Amabel Formation from Waterdown to Niagara Falls): thin- to massive-bedded, fine- to medium-grained dolostone. Thickness: Amabel Formation: maximum observed thickness of 84 feet (26 m). Lockport Formation: up to 130 feet (40 m). Uses: The Lockport and Amabel Formations have been used to produce lime, crushed stone, concrete aggregate and building stone throughout their area of occurrence, and are a resource of provincial significance. Los Angeles Abrasion Test: 21-35% loss; Soundness Test: 2.0% loss; Absorption: 0.4-1.6%.

ONONDAGA FORMATION (MIDDLE DEVONIAN)

(Equivalent to the Detroit River Group, with a textural change) Composition: Edgecliff Member: medium-bedded, fine- to medium-grained, dark grey cherty limestone with an estimated thickness of 25 to 30 feet (8 to 9 m). Clarence Member: massive-bedded, dark grey brown, fine-grained, very cherty limestone having an estimated thickness of 26 feet (8 m). Moorehouse Member: medium-bedded, dark grey brown or purplish brown, fine- to coarse-grained, variably cherty limestone with an estimated thickness of 15 to 25 feet (5 to 8 m). Uses: Quarried for crushed stone on the Niagara Peninsula at Welland and Port Colborne. High chert content makes much of the material unsuitable for concrete aggregate.

OTTAWA FORMATION (MIDDLE ORDOVICIAN)

Composition: Lower Phase (Lowville and Pamela Beds): shale, some sandstone and dolostone. Thickness: 100 feet (30 m). Middle Phase (Hull, Rockland, and Leray Beds): pure, thick-bedded, crystalline limestone. Thickness: 150 feet (46 m) near Ottawa. Upper Phase (Cobourg and Sherman Fall Beds): pure and impure crystalline limestone with few to numerous shaly partings, 450 to 475 feet (137 to 145 m) thick near Ottawa. Uses: The Leray, Rockland, and Hull Beds have been quarried extensively for crushed stone and for building stone. In addition, the Hull Beds are an excellent source of lime for cement production and agricultural uses.

OXFORD FORMATION (LOWER ORDOVICIAN)

Composition: Medium- to thick-bedded, grey dolostone, with some shaly partings. Thickness: 240 feet (73 m). Uses: Quarried for crushed stone (road and concrete aggregate) at Ottawa, Brockville, and Smiths Falls.

BEDROCK SUITABLE FOR LIME PRODUCTION AND OTHER CHEMICAL USES

DETROIT RIVER GROUP (MIDDLE DEVONIAN)

(Equivalent to the Onondaga Formation in the Niagara Peninsula, with a textural change) Composition: Near Beachville, the group consists of medium- to micro-crystalline, medium-bedded, high-purity limestone. It grades northwards near St. Marys to soft, evenly bedded, fine-grained dolostone with bituminous laminae. Massive, porous, reef facies material also occurs to the north (Formosa Reef Limestone). Thickness: 100 feet (30 m) at Beachville, 350 feet (107 m) at Clinton. Uses: The most important source of high-purity limestone in Ontario is the Lucas Formation of the Detroit River Group at Beachville. Detroit River limestone produces 80% of Ontario's cement. Its dolomitic reefal facies is also important for lime production to the north. It is generally unsuitable for crushed stone. The Anderdon Member of the Lucas Formation is quarried at Amherstburg for

crushed stone.

GRENVILLE MARBLE (PRECAMBRIAN)

Composition: Recrystallized white limestone and dolostone, fine- to coarse-grained, usually of high chemical purity. Uses: Lime production, but also in small amounts for terrazzo chips, poultry grit, decorative stone, and building stone.

GUELPH FORMATION (MIDDLE SILURIAN)

Composition: Aphanitic to medium-crystalline, thick-bedded, soft, porous dolostone, characterized in places by extensive vuggy, porous reefal facies dolostone of high chemical purity. The Guelph Formation and the underlying Amabel Formation have a combined thickness of 200 feet (61 m) on the Niagara Peninsula and more than 400 feet (122 m) on the Bruce Peninsula. Uses: The main use is for dolomitic lime in the construction industry. The formation is quarried near Hamilton and Guelph.

LINDSAY FORMATION (MIDDLE ORDOVICIAN)

Composition: Lower Member: fine-crystalline, rubbly, nodular-weathering limestone. Upper Member: grey calcareous claystone with shaly partings and bioclastic layers. The rock is "soft" and weathers to rubble. Both members are characterized by low dolomite content and by numerous clayey partings. Uses: Quarried at Picton, Ogden Point and Bowmanville for cement. The formation is generally unsuitable for crushed stone, concrete aggregate, or granular base course.

VERULAM FORMATION (MIDDLE ORDOVICIAN)

Composition: Fossiliferous, pure to argillaceous limestone and interbedded calcareous shale. The rock is not resistant to erosion and commonly weathers to rubble. Thickness: 200 to 300 feet (61 to 91 m). Uses: Quarried at Picton, Ogden Point, and Mara Township for cement. The formation is unsuitable for crushed stone due to clay impurities, many clayey interbeds, and low abrasion resistance, high soundness losses and poor freeze and thaw resistance.

BEDROCK SUITABLE FOR BRICK AND TILE MANUFACTURE

GEORGIAN BAY FORMATION (UPPER ORDOVICIAN)

(Formerly known as the Meaford-Dundas and Blue Mountain shales in the Toronto and Bruce Peninsula areas) Composition: Soft, fissile, blue grey shale with limey or sandy lenses in a few places. Thickness: 640 feet (195 m) at Toronto. Uses: Several producers in Metro Toronto and Cooksville produce brick and structural tile. Lightweight aggregate is also produced at Streetsville by heat expansion of the shale.

HAMILTON GROUP (MIDDLE DEVONIAN)

Composition: Grey shale with interbeds of crystalline and cherty limestone. The group has six formations, but only the Arkona is of commercial value. It is a soft, light grey, calcareous shale which is plastic and easily worked when wet. Thickness: 80 to 300 feet (24 to 91 m). Uses: The Arkona Formation is extracted at Thedford and near Arkona for production of drainage tile and brick.

QUEENSTON FORMATION (UPPER ORDOVICIAN)

Composition: Red, thin- to thick-bedded, sandy to argillaceous shale with green mottling and banding. Thickness: 400 to 500 feet (122 to 152 m). Uses: There are several large shale quarries developed in the Queenston Formation in the Toronto-Hamilton region and one at Russell, near Ottawa. All produce brick for construction. The Queenston Formation is the most important source material for brick manufacture in the Province.

BEDROCK SUITABLE FOR OTHER INDUSTRIAL PRODUCTS

NEPEAN (POTSDAM) FORMATION (CAMBRO-ORDOVICIAN)

Composition: Creamy, coarse-grained, silica sandstone. Uses: Quarried throughout its area of outcrop for building stone, decorative stone, abrasives, and for glass making.

SALINA FORMATION (UPPER SILURIAN)

Composition. Grey and red shale, brown dolomite, and, in places, salt, anhydrite, and gypsum.

The formation consists predominantly of evaporite deposits with up to eight members identified. Uses: Gypsum is mined at Hagersville, Caledonia, and Drumbo. Salt is mined at Goderich and is produced from brine wells at Amherstburg, Windsor, and Sarnia.

WHITBY FORMATION (UPPER ORDOVICIAN)

(Formerly known as Collingwood Shale near Toronto) Composition: Brown to black fissile shale. Uses: Quarried at Bowmanville for use in cement production. Testing indicates that the Whitby Formation may produce satisfactory lightweight expanded aggregate.

TP OF SCUGOG
TOWN OF NEWCASTLE
Burketon Station
Gravel Pit
Kilns
Silo
Kiln
Gravel Pits
New Park
VICTORIC CO
CANADIAN PACIFIC
1078
1030
1011
BM 938
BM 656
891
Enfield
Bowmanville Creek
Enniskillen
Haydon
Tyrone
Orchards
Orchard
Ditch
Dam
Pump Station
Gravel Pit
Kirby
2 Lines
4 Lines
I
II
III
IV
V
VI
VII
VIII
X
1
2
3
4
5
6
7
8
9
10
11
12
14
15
16
30
35
115

Ministry of Natural Resources
Ontario

Hon. Alan W. Pope
Minister

J. R. Sloan
Deputy Minister

ONTARIO GEOLOGICAL SURVEY
AGGREGATE RESOURCES INVENTORY

TOWN OF NEWCASTLE
REGIONAL MUNICIPALITY OF DURHAM

MAP 2
SELECTED SAND AND GRAVEL RESOURCE AREAS

Scale 1:50 000

Mile 1 0 1 Mile

Metres 1000 0 1 Kilometre

NTS Reference: 30 M/15 30 M/16
31 D/1 31 D/2

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SYMBOLS

(Some symbols may not apply to this map.)

- Geological and aggregate thickness boundary.
- Buried geological and aggregate thickness boundary.
- Municipal boundary.
- Selected sand and gravel resource area; Primary significance; Deposit number: see Table 3.
- Selected sand and gravel resource area; Secondary significance.

TP OF SCUGOG
TOWN OF NEWCASTLE
VICTORIA CO
R.M. OF DURHAM
CANADIAN PACIFIC
WHITBY FORMATION
LINDSAY FOR
Burketon Station
Enniskillen
Tyrone
Haydon
Enfield
Bowmanville Creek
New Park
Leskard
Gravel Pit
Gravel Pits
Kilns
Kiln
Orchards
Orchard
Sports Track
Gate
Dam
Pump Station
Mackie's
Bowmanville Creek
Wilmot Creek
Kirby
2 Lines
4 Lines
BM 938
BM 656
1078
1030
1011
1105
891
904
I
II
III
IV
V
VI
VII
VIII
IX
X
>120
>199
>140
>240
>255
>336
>108
>367
>205
>153
>145
>202
>166
>165
>117
>138
>152
>258
>245
>161
>163
>210
>355
>263
>320
>332
>182
>231
>252
>102
>205
>199
>130
>91
>102
>64
>195
495
>57
188
>125
702
35
115

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Hon. Alan W. Pope
Minister
J. R. Sloan
Deputy Minister

ONTARIO GEOLOGICAL SURVEY
AGGREGATE RESOURCES INVENTORY

TOWN OF NEWCASTLE
REGIONAL MUNICIPALITY OF DURHAM

MAP 3
BEDROCK RESOURCES

Scale 1:50 000

Mile 1 0 1 Mile
Metres 1000 0 1 Kilometre

NTS Reference: 30 M/15 30 M/16
31 D/1 31 D/2

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LEGEND

PALEOZOIC

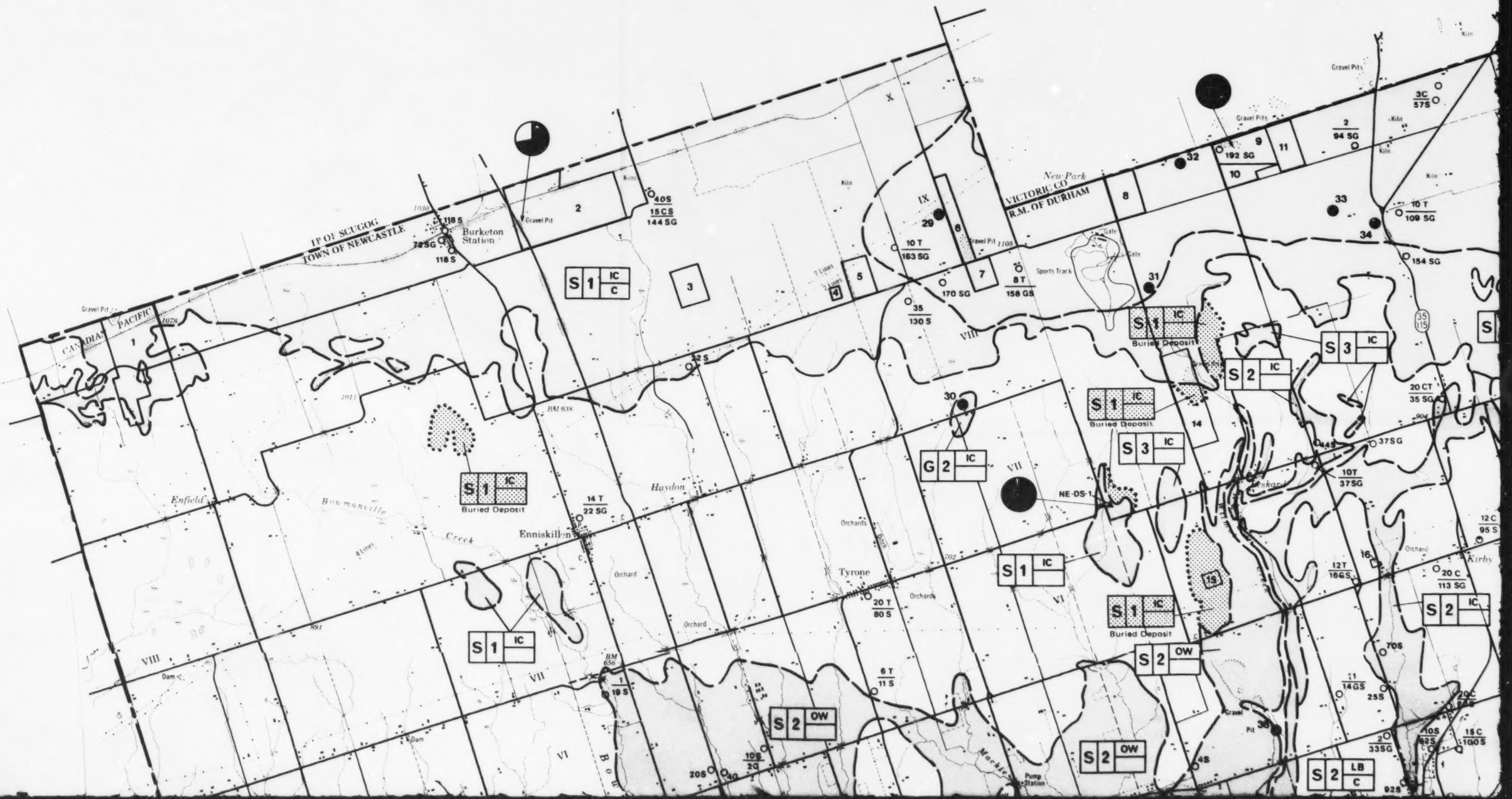
ORDOVICIAN

UPPER ORDOVICIAN

WHITBY FORMATION
Grey and black shale

SIMCOE GROUP
Limestone

LINDSAY FORMATION
Limestone


TP OF SCUGOG
TOWN OF NEWCASTLE
CANADIAN PACIFIC
Burketon Station
Gravel Pit
118 S
78 SG
40S
15CS
144 SG
2
3
S 1 IC C
Enfield
Bowmanville Creek
Haydon
Enniskillen
Orchard
Tyrone
Orchards
Ditch
Silo
Kiln
Gravel Pits
New Park
VICTORIA CO
R.M. OF DURHAM
IX
VIII
VII
VI
29
6
5
7
8
9
10
11
32
33
34
31
30
192 SG
10 T
163 SG
170 SG
8 T
158 GS
35
130 S
3C
57S
2
94 SG
10 T
109 SG
154 SG
Sports Track
Gate
Buried Deposit
S 1 IC
S 2 IC
S 3 IC
G 2 IC
S 2 OW
S 2 LB C
NE-DS-1
14 T
22 SG
20 T
80 S
6 T
11 S
20 CT
35 SG
37SG
10T
37SG
12T
16GS
20 C
113 SG
12 C
95 S
154 SG
Pump Station
Manhole
Dam
BM 938
BM 656
1078
1011
891
702
1030
1105

MANVERS TP
TOWN OF NEWCASTLE

Microwave 250

Gravel Pits

Orchard

Kiln

Sports Track

Greenhouse

Auto Wrecker

Kendal

Kirby

Starkville

Ski Lift

Pumphouse

TOWN OF NEWCASTLE

HOPE TP

S 1 IC C

G 1 IC

S 1 OW

S 1 IC

S 3 IC

S 2 IC

S 2 LB

S 1 LP

12 13

3C 57S

2 94 SG

9 192 SG

11

10

33

34

10 T 109 SG

154 SG

25 83 SG

751SG

20 CT 35 SG

37SG

10T 37SG

12T 16GS

12 C 95 S

20 C 113 SG

16

30 C 170 GS

70S

11 14GS

25S

2 33SG

10S 62S

15C 100S

12S 14C 44SG

18 GS

16 166 SG

17

200 65S

1 20S

I

II

III

IV

V

VI

VII

VIII

IX

X

100

633

649

938

904

N

ONT

TO

REGION

DIS

Mile

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SYMBOLS

(Some symbols may not apply to this map.)

Geological and aggregate thickness b
indicates deposit area.

Buried geological and aggregate thi
Shading indicates deposit area.

Municipal boundary.

Ontario

Ministry of Natural Resources

Hon. Alan W. Pope
Minister

J. R. Sloan
Deputy Minister

ONTARIO GEOLOGICAL SURVEY

AGGREGATE RESOURCES INVENTORY

TOWN OF NEWCASTLE

REGIONAL MUNICIPALITY OF DURHAM

MAP 1
DISTRIBUTION OF SAND AND GRAVEL DEPOSITS

Scale 1:50 000

Mile 1 0 1 Mile

Metres 1000 0 1 Kilometre

NTS Reference: 30 M/15 30 M/16
31 D/1 31 D/2

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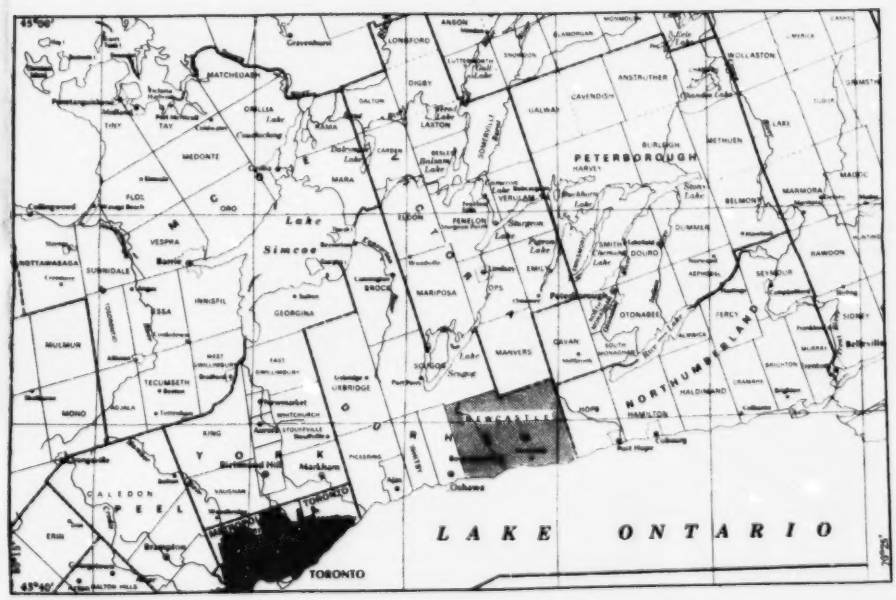
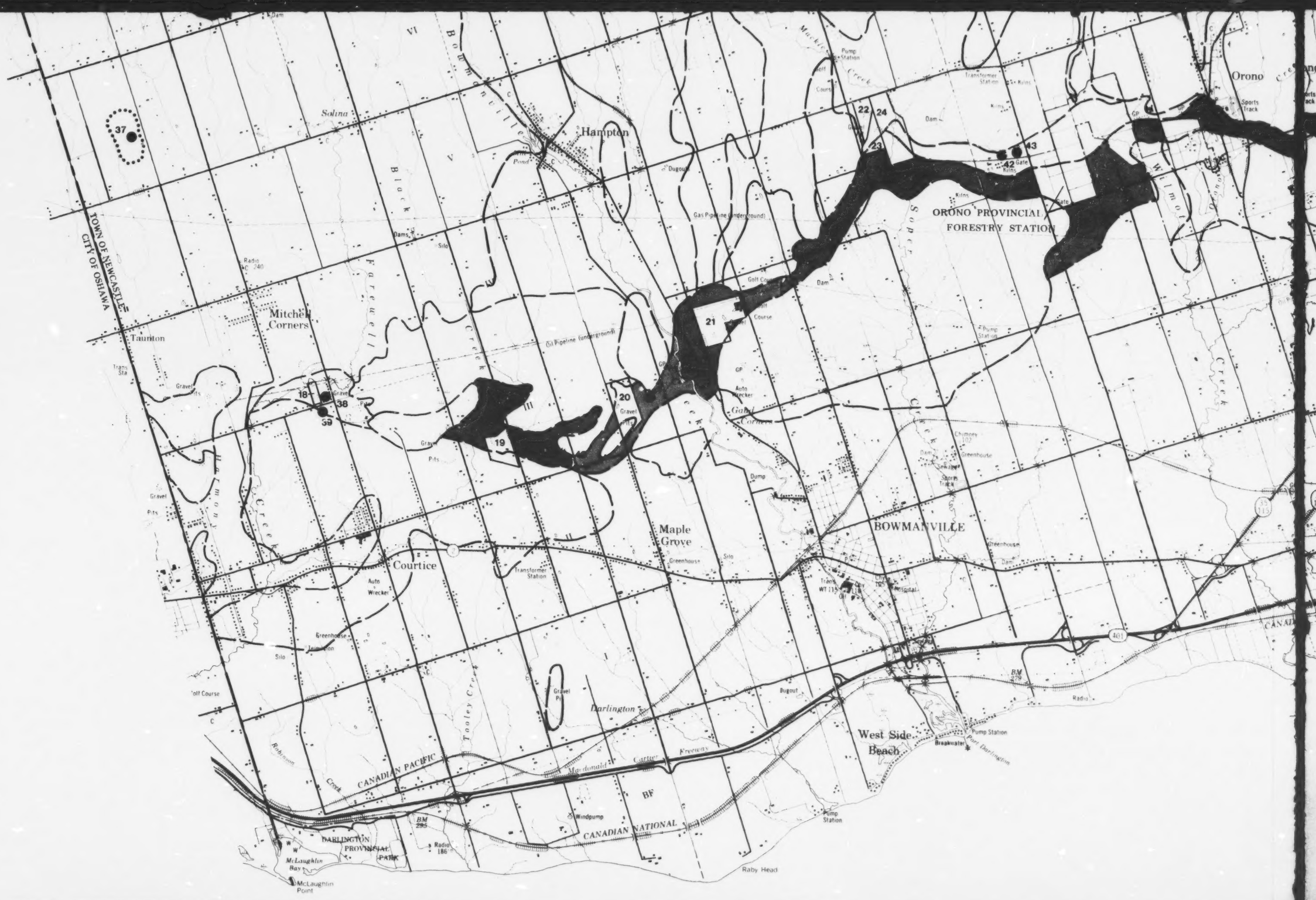

PETERBOROUGH
NORTHUMBERLAND
NEWCASTLE
Lake Simcoe
LAKE ONTARIO
TORONTO
Oshawa
Markham
Richmond Hill
Whitchurch
Stouffville
Uxbridge
Brock
Scugog
Rama
Georgina
Innisfil
Essa
Tecumseth
Adjala
Mono
Mulmur
Orillia
Barrie
Bradford
Newmarket
Aurora
Vaughan
Caledon
Peel
York
Durham
Simcoe
Victoria
Haliburton
Kawartha Lakes
Clarington
Port Hope
Cobourg
Brighton
Trenton
Belleville
Quinte West
Prince Edward
Hastings
Lennox and Addington
Frontenac
Kingston
Gananoque
Brockville
Leeds and Grenville
Smiths Falls
Perth
Stratford
Kitchener
Waterloo
Cambridge
Guelph
Halton
Hamilton
Burlington
Oakville
Milton
Brampton
Mississauga
Dufferin
Orangeville
Shelburne
Grey
Owen Sound
Meaford
Collingwood
Wasaga Beach
Midland
Penetanguishene
Tiny
Severn
Gravenhurst
Bracebridge
Huntsville
Muskoka
Parry Sound
Nipissing
North Bay
Mattawa
Temagami
Timiskaming
Cochrane
Timmins
Kapuskasing
Hearst
Algoma
Sault Ste. Marie
Manitoulin
Sudbury
Greater Sudbury
Espanola
Elliot Lake
Blind River
Thessalon
Wawa
Chapleau
Kirkland Lake
Temiskaming Shores
New Liskeard
Haileybury
Cobalt
Englehart
Kenora
Dryden
Fort Frances
Rainy River
Atikokan
Thunder Bay
Nipigon
Geraldton
Longlac
Marathon
Terrace Bay
Schreiber
Red Lake
Ear Falls
Sioux Lookout
Pickle Lake
Ignace
Kenora
Rainy River
Manitoulin
Sudbury
Algoma
Cochrane
Timiskaming
Nipissing
Parry Sound
Muskoka
Haliburton
Kawartha Lakes
Peterborough
Northumberland
Prince Edward
Hastings
Lennox and Addington
Frontenac
Leeds and Grenville
Lanark
Renfrew
Ottawa
Prescott and Russell
Stormont, Dundas and Glengarry
Cornwall
Brockville
Smiths Falls
Perth
Huron
Bruce
Grey
Dufferin
Wellington
Waterloo
Perth
Oxford
Brant
Norfolk
Haldimand
Niagara
Hamilton
Halton
Peel
York
Durham
Simcoe
Victoria


Solina
Hampton
Orono
Mitchell Corners
Taunton
Courtice
Maple Grove
Darlington
West Side Beach
BOWMANVILLE
ORONO PROVINCIAL FORESTRY STATION
TOWN OF NEWCASTLE
CITY OF OSHAWA
Black Creek
Farewell Creek
Tooley Creek
Robinson Creek
Soper Creek
Wilmot Creek
Oil Pipeline (underground)
Gas Pipeline (underground)
CANADIAN PACIFIC
CANADIAN NATIONAL
Macdonald Cartier Freeway
401
DARLINGTON PROVINCIAL PARK
McLaughlin Bay
McLaughlin Point
Raby Head
Port Darlington
Golf Course
Auto Wrecker
Transformer Station
Pump Station
Greenhouse
Gravel Pits
Windpump
Radio
Dump
Sports Track
Hospital
Chimney
Breakwater
Gate
Kilns
Dugout
Silo
Dam
Pond
BM 295
BM 279
BF
37
38
39
18
19
20
21
22
23
24
42
43

significance; Deposit number: see Table 3.

Selected sand and gravel resource area; Secondary significance.

Selected sand and gravel resource area; Tertiary significance.

2 — Licenced property boundary; Property number: see Table 2.

3 — Unlicenced sand or gravel pit*; Property number: see Table 2.
*Abandoned pit or wayside pit operating on demand under authority of a permit.

SOURCES OF INFORMATION

Base map by Surveys and Mapping Branch, Ontario Ministry of Natural Resources.
Licence data from District and Regional Offices, Ontario Ministry of Natural Resources.
Aggregate suitability data from the Engineering Materials Office, Ontario Ministry of Transportation and Communications.

Geology by: W. Deike, 1981.
C. P. Gravenor, 1954a,b, 1957.
O. H. J. Gwyn, 1976.

Compilation and Drafting by: Staff of the Aggregate Assessment Office.

This map is to accompany O.G.S. Aggregate Resources Inventory Paper 94.

This map is published with the permission of V. G. Milne, Director, Ontario Geological Survey.
Issued 1984.

NEWCASTLE

WHITBY FORMATION
ORONO PROVINCIAL FORESTRY STATION
WHITBY FORMATION
BOWMANVILLE
WHITBY FORMATION
LINDSAY FORMATION
WHITBY FORMATION
Hampton
Mitchell Corners
Taunton
Courtice
Maple Grove
Darlington
Gaud Corners
Orono
West Side Beach
Salina
TOWN OF NEWCASTLE
CITY OF OSHAWA
Black Creek
Farewell Creek
Bowmanville Creek
Soper Creek
Tooley Creek
Robinson Creek
Mill Pond
Mackie Creek
CANADIAN PACIFIC
CANADIAN NATIONAL
Gas Pipeline (underground)
Oil Pipeline (underground)
Golf Course
Gravel Pits
Dams
Silo
Radio
Pump Station
Transformer Station
Greenhouses
Kilns
Dugouts
Auto Wrecker
Windpump
Chimney
Breakwater
Pump Station
Sports Track
Baby Head
McLaughlin Point
McLaughlin Bay
DARLINGTON PROVINCIAL PARK
401

NEWCASTLE

Limestone

LINDSAY FORMATION
Limestone

SYMBOLS

(Some symbols may not apply to this map.)

- Geological formation boundary.
- Geological formation member boundary.
- Formation thickness boundary (see text).
- 25 — Drift thickness contour: 25 foot (8 m) interval.
- Municipal boundary.
- (2) Selected bedrock resource area; Deposit number: see Table 6.
- Bedrock exposed or near surface; covered by less than 3 feet (1 m) of overburden: see Table 4.
- Bedrock covered by 3 to 25 feet (1 to 8 m) of overburden: see Table 4.
- Bedrock covered by 25 to 50 feet (8 to 15 m) of overburden: see Table 4.
- x Isolated bedrock outcrop.
- Q2 Licenced quarry boundary; Property number: see Table 5.
- ● Q3 Unlicenced quarry*; Property number: see Table 5. *Abandoned quarry or wayside quarry operating on demand under authority of a permit.
- O 28 Selected drilled waterwell location; reported depth to bedrock (in feet).

SOURCES OF INFORMATION

Base map by Surveys and Mapping Branch, Ontario Ministry of Natural Resources.
Licence data from District and Regional Offices, Ontario Ministry of Natural Resources.
Aggregate suitability data from the Engineering Materials Office, Ontario Ministry of Transportation and Communications.
Selected drilled water well data from the Ontario Ministry of the Environment.
Drilling data from the Petroleum Resources Section, Ontario Ministry of Natural Resources.

Geology by: D.M. Carson, 1980.
B.A. Liberty, 1969.
S.N. Singer, 1974.

Compilation and Drafting by: Staff of the Aggregate Assessment Office.

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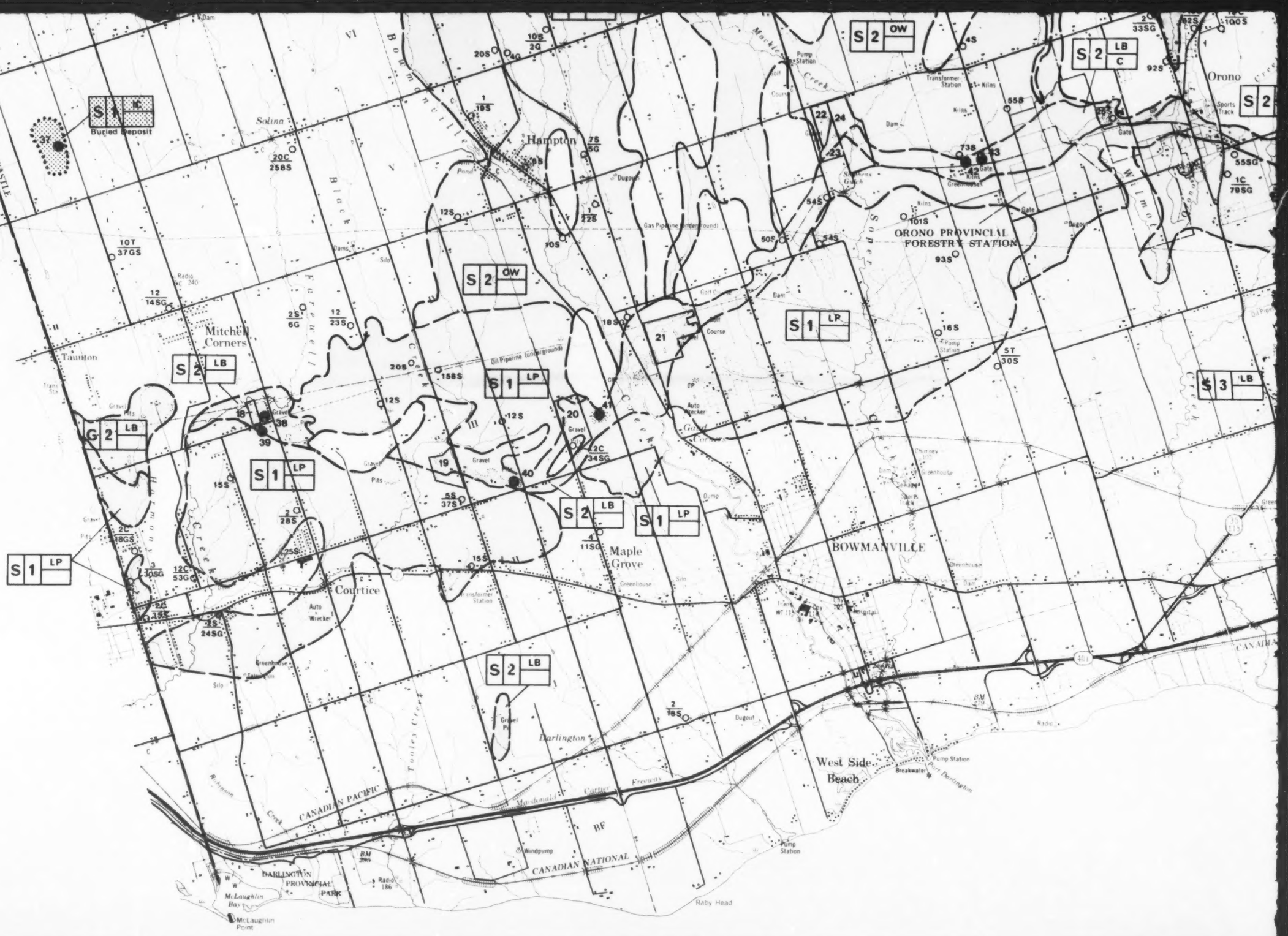
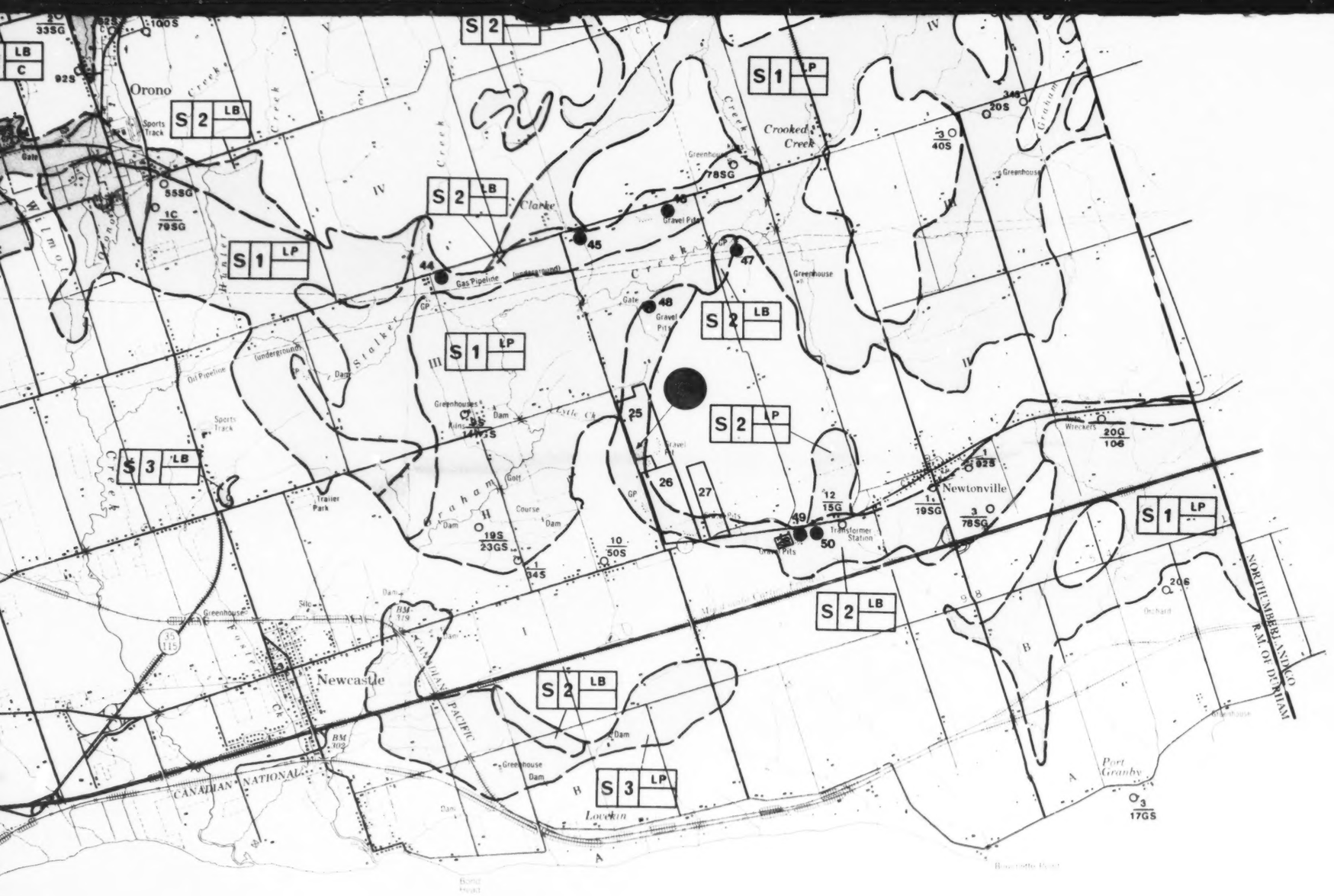
Issued 1984.


TOWN OF NEWCASTLE
CITY OF OSHAWA
Buried Deposit
Solina
Hampton
Mitchell Corners
Taunton
Courtice
Maple Grove
Darlington
Orono
ORONO PROVINCIAL FOREST STATION
BOWMANVILLE
West Side Beach
Port Darlington
DARLINGTON PROVINCIAL PARK
McLaughlin Bay
McLaughlin Point
Raby Head
Black Creek
Bowmanville Creek
Soper Creek
Tooley Creek
Robinson Creek
Mackie Creek
Farewell
Gravel Pits
Auto Wrecker
Windpump
Pump Station
Transformer Station
Sports Track
Greenhouse
Dugout
Silo
Radio
Gas Pipeline (underground)
Oil Pipeline (underground)
CANADIAN PACIFIC
CANADIAN NATIONAL
Macdonald Cartier Freeway
Golf Course
Dump
Hospital
Breakwater
Pump Station
Gate
Kilns
Dam
Pond
Creek
BM 295
BM 279
Radio 186
401



NEWCASTLE

Buried geological and aggregate thickness boundary. Shading indicates deposit area.

Municipal boundary.

2 — Licenced property boundary; Property number: see Table 2.

3 — Unlicenced sand or gravel pit*; Property number: see Table 2.
*Abandoned pit or wayside pit operating on demand under authority of a permit.

NE-DS-2 — Described section; Identification number: see Table 7.

6 / 23 G — Selected drilled water well location; reported thickness of material (in feet); reported type of material (number only - overburden, T - till, G - gravel, S - sand, C - clay, Bk - bedrock).

G 1 IC C-O — Deposit Symbol: see below.

Texture symbol: see below.

DEPOSIT SYMBOL

Gravel Content — G 1 IC C-O — Geological Type

Thickness Class — Quality Indicator

Deposits are identified by Gravel Content, Thickness Class, Geological Type and Quality Indicator. Gravel Content is expressed as a percentage of gravel-sized material (i.e. material retained on the 4.75 mm sieve). Thickness Class is based on potential aggregate tonnage per acre. Geological Type refers to geologic origin. Quality Indicator describes objectionable grain size and lithology.

Gravel Content

G Greater than 35% gravel.
S Less than 35% gravel.

SOURCES OF I

Base map by Surveys and Mapping Branch, Ontario Ministry of Natural Resources.
Licence data from District and Regional Offices, Ontario Ministry of Natural Resources.
Aggregate suitability data from the Engineering Materials Office, Ontario Ministry of Transportation and Communications.
Test hole data from Aggregate Assessment Office, Ontario Geological Survey, Ontario Ministry of Natural Resources.
Selected drilled water well data from the Ontario Ministry of the Environment.
Drilling data from the Petroleum Resources Section, Ontario Ministry of Natural Resources.

Geology by: W. Deike, 1981.
C. P. Gravenor, 1954a,b, 1957.
Q. H. J. Gwyn, 1976.

Geological and aggregate-thickness boundary. Shading indicates deposit area.

Buried geological and aggregate thickness boundary. Shading indicates deposit area.

Municipal boundary.

Licenced property boundary; Property number: see Table 2.

Unlicenced sand or gravel pit*; Property number: see Table 2.
*Abandoned pit or wayside pit operating on demand under authority of a permit.

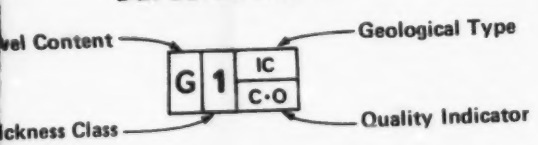
Described section; Identification number: see Table 7.

Selected drilled water well location; reported thickness of material (in feet); reported type of material (number only - overburden, T - till, G - gravel, S - sand, C - clay, Bk - bedrock).

Deposit Symbol: see below.

Texture symbol: see below.

DEPOSIT SYMBOL



dentified by Gravel Content, Thickness Class, Geological Type ddicator. Gravel Content is expressed as a percentage of gravel- (i.e. material retained on the 4.75 mm sieve). Thickness Class otential aggregate tonnage per acre. Geological Type refers to n. Quality Indicator describes objectionable grain size and

eater than 35% gravel.
ss than 35% gravel.

1	greater than 20 (> 6)	greater than 50,000 (> 112 000)
2	10-20 (3-6)	25,000-50,000 (56 000 - 112 000)
3	5-10 (1.5-3)	12,500 - 25,000 (28 000 - 56 000)
4	less than 5 (< 1.5)	less than 12, 500 (< 28 000)

Geological Type

AL	Older Alluvium	**K**	Kame
E	Esker	**LB**	Lacustrine Beach
EM	End Moraine	**LD**	Lacustrine Delta
IC	Undifferentiated Ice-Contact Stratified Drift	**LP**	Lacustrine Plain
		OW	Outwash
ICT	Ice-Contact Terrace	**WD**	Windblown Forms

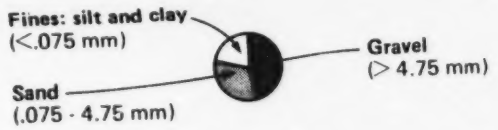
(see Appendix C for descriptions of Geological Types)

Quality Indicator

	If blank, no known limitations present.
C	Clay and/or silt (fines) present in objectionable quantities.
L	Deleterious lithologies present.
O	Oversize particles or fragments present in objectionable quantities.

TEXTURE SYMBOL

(This symbol is used where sample analysis data are available.)



The Texture Symbol provides quantitative assessment of the grain size distribution at a sampled location. The relative amounts of gravel, sand, silt and clay in the sampled material are shown graphically by the subdivision of a circle into proportional segments. The above example shows a hypothetical sample consisting of 45% gravel, 35% sand and 20% silt and clay.

SOURCES OF INFORMATION

Surveys and Mapping Branch, Ontario Ministry of Natural Re-

from District and Regional Offices, Ontario Ministry of Natural

itability data from the Engineering Materials Office, Ontario f Transportation and Communications.
a from Aggregate Assessment Office, Ontario Geological Survey, inistry of Natural Resources.
ed water well data from the Ontario Ministry of the Environment.
from the Petroleum Resources Section, Ontario Ministry of esources.

W. Deike, 1981.

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Issued 1984.

Information quoted for an individual test hole or pit refers to a specific sample or face. Care should be exercised in extrapolating such information to other parts of the deposit.